

1990 EMISSIONS INVENTORY OF SECTION 112(c)(6) POLLUTANTS:

**POLYCYCLIC ORGANIC MATTER (POM),
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD)/
2,3,7,8-TETRACHLORODIBENZOFURAN (TCDF),
POLYCHLORINATED BIPHENYL COMPOUNDS (PCBs),
HEXACHLOROBENZENE, MERCURY, AND
ALKYLATED LEAD**

Final Report

Distributed by:

**Emission Factor and Inventory Group (MD-14)
Emissions, Monitoring and Analysis Division
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711**

and

**Visibility and Ecosystem Protection Group (MD-15)
Air Quality Strategies and Standards Division
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711**

June 1997

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1.0 INTRODUCTION

1.1 Background and Purpose

Section 112(c)(6) of the Clean Air Act Amendments (CAAA) of 1990 prescribes the following regulatory program for seven specific pollutants:

With respect to alkylated lead compounds, polycyclic organic matter, hexachlorobenzene, mercury, polychlorinated biphenyls, 2,3,7,8-tetrachlorodibenzofurans and 2,3,7,8-tetrachlorodibenzo-p-dioxin, the Administrator shall, not later than 5 years after the date of enactment of the Clean Air Act Amendments of 1990, list categories and subcategories of sources assuring that sources accounting for not less than 90 per centum of the aggregate emissions of each such pollutant are subject to standards under subsection (d)(2) or (d)(4). Such standards shall be promulgated not later than 10 years after such date of enactment. This paragraph shall not be construed to require the Administrator to promulgate standards for such pollutants emitted by electric utility steam generating units."

In order to meet the requirements of Section 112(c)(6), national inventories of sources and emissions of these seven specific pollutants are needed. These inventories will provide the reference basis for the development of a national strategy to control the Section 112(c)(6) pollutants. These same national inventories will prove equally useful as input to the urban area source program pursuant to Section 112(k) of the CAAA, should any of these pollutants also be selected under that program as presenting a threat to public health in urban areas. Because the seven specific pollutants in Section 112(c)(6) are of particular interest to the Great Waters program, these inventories will also prove useful in the context of implementing Section 112(m), dealing with the protection of the Great Lakes and coastal estuaries.

The purpose of this report is to present the results of a national inventory of the seven specific Section 112(c)(6) pollutants: polycyclic organic matter (POM), polychlorinated biphenyls (PCB), 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF), 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), hexachlorobenzene (HCB), mercury, and alkylated lead.

Readers should be aware that the definition of POM used for the purposes of this Section 112(c)(6) emissions inventory is not the same as the POM definition contained in the Clean Air Act. The POM definition in Section 112(b) of the Act, which is currently under review by EPA, is based on chemical and structural principles of the subject compounds. This type of definition leads to there being possibly thousands of compounds that could qualify as POM. From a practical standpoint, it would not be feasible to inventory all of these potential POM species from all sources. Instead, EPA has opted for a different approach in which specific groups of POM compounds have been listed as surrogates and these groups constitute "POM" for the purposes of this inventory. Two groups have been used, one consisting of 7 POM compounds and one consisting of 16 species. In addition, a third approach is also presented in which POM mixtures have been approximated by using the extractable organic matter (EOM) fraction of particulate matter samples. The use of the EOM approach is limited in that data do not exist for many source categories. A more detailed and thorough discussion of the POM definitions and the methods used for this inventory are presented in Chapter 3.0, Sections 3.1 and 3.2.

The base year for each inventory was selected by EPA to be 1990. A 1990 base year was used because this was the year the most recent Clean Air Act amendments were enacted and the 112(c)(6) requirements came into force. Hence, to the extent practicable, emissions, activity, and control information are presented for 1990 rather than for the present. Any subsequent emission reductions to meet the requirements of Section 112(c)(6) are thus credited with respect to 1990 base year levels. In a limited number of cases, 1990 base year emission estimate data were not available (either emissions or source activity or both) and therefore, a different base year (as close to 1990 as the data would allow) had to be used. These cases can be determined from the inventory documentation.

For several of the source categories presented in this inventory, 112(c)(6) pollutant emissions from 1990 to the present have been significantly reduced due to the development and promulgation of various National Emission Standards for Hazardous Air Pollutants (NESHAPs), which contain Maximum Achievable Control Technology (MACT) requirements.

Therefore, for some source categories, the 1990 emission inventory estimates shown in this document are not representative of current emissions due to significant reductions the affected industries have made. For categories where a MACT standard has been put into place and where a more current (e.g., 1995) emission estimate is available (usually through the MACT development effort), these estimates are also provided in the emission estimate tables along with the baseline 1990 value.

The national inventory surveys presented in this report include all known sources of each pollutant, both mobile and stationary. All of these sources and emissions may not be subject to the provisions of Section 112(c)(6) or 112(k) (e.g., mobile sources, forest fires, and pesticide application), and may need to be culled out for strategy development purposes. The provisions of Section 112 focus specifically on stationary sources.

Preparation of these inventories consisted of identifying all sources of emissions of the seven specific pollutants, estimating the national emissions for all source categories in various ways, and distinguishing between emissions from major and area source categories (as defined in Section 112(a) of the CAAA and considering the definition of co-located sources in 57 FR 31576).

Various conventions were adopted for inventorying some of these specific pollutants where no standardized methods currently exist. As discussed previously, this is most notably the case for POM, which is a complex mixture of thousands of polynuclear aromatic hydrocarbons (PAH) and PAH derivatives. For POM, several inventory approaches are presented. One approach assumes that the solvent extractable fraction of particulate matter (hereafter referred to as EOM) is a valid surrogate for POM. Other approaches adopted here assume that specific groupings of individual PAH are representative of total POM. One surrogate grouping includes 16 PAHs and another grouping consists of 7 PAH compounds. Rationale for these choices of surrogates are presented later in this report (Chapter 3.0).

For dioxins and furans, this report inventories the individual dioxin and furan congeners identified in Section 112(c)(6), but also inventories 2,3,7,8-TCDD toxic equivalents (TEQ), which is a single aggregate measure of all dioxin and furan congeners, considering the relative toxicities of each. It should be noted, however, that individual congener data were not readily available for emission estimation purposes for every source category. For this reason, only TEQ emissions are reported for some categories.

1.2 Overview of the Inventory Development Process

The purpose in this discussion is to help the reader better understand the nature of the data presented in this report, and better understand differences in the data (both in form and content). This document essentially contains a summary of several detailed emission inventory development efforts that have been conducted for Section 112(c)(6) pollutants. The intent is to provide the reader with national emission inventory totals by pollutant/source category and concise documentation sufficient to understand the basic concepts behind how the totals were generated. The initial 112(c)(6) inventory development process started about two and a half years ago. One group assessed POM, PCB, dioxin, and furan emissions, one group assessed HCB and alkylated lead emissions, and a third group assessed mercury sources and emissions. The data that were available for this document are predominantly summaries generated by these separate groups. While all three efforts had similar scopes and oversight by the same EPA groups, the inventory development efforts were nonetheless separate and not always completely identical in approach. Many of the differences in the type and format of summary data presented in the report for a given pollutant/source category are the result of the differences in how the original development efforts addressed the situation, and the level of effort that was expended to pursue certain data and source categories.

The efforts with the greatest similarity are the POM/PCB/dioxin/furan data and the HCB/alkylated lead data. The available inventory data, how the data were developed, and how emission allocations were done are reasonably similar for these pollutants and their sources. However, the mercury information is somewhat different. The mercury data

presented in this report are the product of an extensive EPA effort to compile a Report to Congress on mercury in order to meet a mandate in the 1990 CAAA. Significantly more effort and resources went into the compilation of the Mercury Report to Congress than was expended to conduct the research efforts on the other 112(c)(6) pollutants. The mercury data provided in this inventory report are a summary of the information reported in the Report to Congress.

For all of these inventory data development efforts, the process has been an ongoing one with updates to estimates occurring routinely. Updates from the originally developed data have come as the result of ongoing programs such as EPA's MACT standards programs, EPA Locating and Estimating (L&E) document projects, EPA's urban area toxics program, the Toxics Release Inventory (TRI) program, and the Great Waters program. Because there are multiple programs investigating air toxics emissions in the United States, emissions estimates are constantly in flux. For this reason, it is very difficult to always keep all estimates consistent. Applicable emissions data and the associated source activity data are ever changing. The data presented in this document reflect values that have been developed given the assumptions and input data documented in the report. They are applicable for a specific time period. They may not necessarily agree with the national estimates from other sources due to differences in time period, input emission and activity data, and calculation assumptions. It should be recognized that some of the data presented here as 112(c)(6) estimates will likely change as more information and improved estimation approaches are developed.

1.3 Report Organization

Chapter 2.0 contains a description of the general methodologies, approaches, and data sources used to compile the 112(c)(6) pollutant national estimates. Limitations and shortcomings in the available data are also covered. Chapters 3.0 through 8.0 describe the general methodology used to determine source categories, emission estimates, and allocation schemes for POM, dioxin/furan, PCBs, mercury, HCB, and alkylated lead, respectively. Each

of these respective sections also presents more detailed summaries of sources and emissions of each pollutant, and data on major versus area source category splits. Data gaps and deficiencies are identified and discussed in Chapter 9.0, along with recommendations for improving the current national estimates.

Appendix A contains specific documentation for the EOM, dioxin/furan, and PCB emission estimates of each source category. The subject pollutants of each category are identified, the input data used to calculate emissions are provided, and the algorithms used to allocate national emissions are presented. Appendix B contains the emission factors, activity data, and emissions calculations, respectively, for the 7-PAH and 16-PAH estimates, which serve as surrogates for POM emissions. The documentation for the mercury, HCB, and alkylated lead estimates is contained within their respective document sections.

2.0 INVENTORY DEVELOPMENT METHODOLOGY

2.1 Inventory Methods Summary

The majority of the national emission estimates developed for 112(c)(6) pollutants are “top-down” estimates. This means they were developed using national level activity data and some measure of emissions that could be applied to these data. Few categories had estimates developed from a true “bottom-up” basis (i.e., estimates developed specifically for individual sources and summed to obtain a national total). In cases where individual facility data were available to inventory a category (e.g., municipal waste combustors), sometimes not all sites could be addressed with site-specific data and default factors and/or activities had to be developed to apply in those cases. In such instances the bottom-up estimates are not fully all site-specific, bottom-up data. The 112(c)(6) national estimates were determined using existing data, such that no new source testing or industry surveys to gauge activity levels were conducted for the specific purposes of 112(c)(6).

The bulk of the estimates were completed by applying an emission factor or series of factors (associated with varying source configurations, material/fuel types, and controls) to a set of activity data (e.g., production rate, fuel input rate, waste disposed rate, and vehicle miles traveled rate) that correlates with the surrogate being used to approximate emissions. As stated in Chapter 1.0, the intent was to obtain activity data that represented 1990 base levels as close as possible. The emission factors were obtained by performing an extensive computerized search of existing literature. The identified data were evaluated for age, completeness, and overall quality. Acceptable data were used to develop composite emission factors for use in the national estimates. In some cases, the emission factors came from the most current version of EPA’s AP-42 document (U.S. EPA, 1995). In most cases, however, factors for the 112(c)(6) hazardous air pollutants (HAPs) were not available in AP-42 and other sources had to be sought out. While no source testing was performed specifically and directly for the 112(c)(6) program, some estimates were based on recent test data, since the estimates came from standards programs where EPA, states, and/or industry had conducted

recent testing. Also, some of the AP-42 estimates represented the results of recent testing to develop new data for AP-42. Most of the source activity data were obtained from published sources such as government statistical documents and databases (e.g., Energy Information Administration fuel consumption reports, Forest Service reports on fires and burned acreage, and Agriculture Department publications on pesticide usage), industry trade publications, and commercially published business directories and journals. For some of the MACT standard-derived estimates, activity data were obtained directly from the affected industry.

In addition to use of the factor times activity method, another general approach that was used involved speciating known emissions, production levels, or waste streams for the subject category based on data that indicated the level of the 112(c)(6) HAP pollutant in the stream. For example, national particulate matter (PM) emissions from a category may have been known from other studies, and if available data indicated that 1.2 percent of the PM emissions from this category are POM, a national estimate for POM could be determined. In a similar manner, in some cases the emissions of a related form of a 112(c)(6) pollutant were known from other studies, and the speciation of the larger pollutant group was known for the 112(c)(6) HAP. Emissions for the 112(c)(6) HAP could then be determined based on the speciation ratio. An example of this would be the estimation of 2,3,7,8-TCDD emissions based on its contribution to total chlorinated dioxin emissions from a category, when the total dioxin emissions were known. In other cases, the speciation of a product (e.g., pesticide) may have been known, and due to the nature of the product and its associated operation, an estimate could be made that all or some fraction of the material (and the HAP constituent) was lost to the atmosphere. The same approach was used for some cases where the pollutant was a constituent of a waste stream from a category and the total amount of waste and the HAP composition of the waste stream were known.

2.2 Major/Area Source Allocations

To better understand the nature and impact of 112(c)(6) pollutant emissions, the national emission estimates were allocated according to whether the emitting source category

was classified as “major,” “area,” or could be classified partially as both. As the name implies, major sources are generally larger with greater per source levels of emissions, while area sources have fewer emissions on a per source basis and may be located in a more dispersive manner. According to Title III, Section 112(a) of the CAAA, a "major source" is any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. An "area source" is any stationary source of HAPs which does not qualify as a major source. The reader should refer to the July 16, 1992 Federal Register notice for a more detailed discussion of the concept of co-location (Federal Register, 1992). The allocation of emissions to a major/area source basis for each source category will be helpful in evaluating the effect of existing and future regulatory programs (e.g., MACT standards) on emissions reductions. For example, existing MACT standards are more geared towards major sources as opposed to area. If it turns out that area sources constitute a large portion of 112(c)(6) emissions, future standards programs may need to consider incorporating more area sources in their applicability determinations.

The major/area allocations that were determined for the purpose of this inventory compilation are presented in Table 2-1. The percentages shown in the table were applied to the total national emissions of each pollutant from each source category to calculate the major and area source emissions for the category. These values take into consideration co-location of processes where data are available. The major/area allocation percentages were derived in a variety of ways. The reader should not treat these percentages and the resulting calculated major/area source emissions as absolutes. They are truly estimates at best. The primary goal was to get a sense of whether a category was predominantly in one group or the other. The rationale used to make the major/area determinations varied depending on available information. The EPA report Documentation for the Development of the Initial Source Category List, which was used to identify major source categories for standards development purposes, was a key reference (U.S. EPA, 1992). In other cases, the accepted

Table 2-1

**Distribution of Major and Area Source Emissions by
Source Category**

| Source Category | Major/Area Source Allocation^a (% Major/% Area) |
|---|--|
| Incineration Sources | |
| Municipal Waste Combustion | 95/5 |
| Medical Waste Incineration | 15/85 |
| Other Biological Incineration | 0/100 |
| Crematories | 0/100 |
| Hazardous Waste Incinerators | 100/0 |
| Lightweight Aggregate Kilns-Hazardous Waste-fired | 100/0 |
| Sewage Sludge Incineration | 0/100 |
| Scrap Tire Incineration | 100/0 |
| Stationary External Fuel Combustion | |
| Electric Utility Coal Combustion | 100/0 |
| Electric Utility Residual Fuel Oil Combustion | 90/10 |
| Electric Utility Natural Gas Combustion | 90/10 |
| Industrial Coal Combustion | 70/30 |
| Industrial Distillate Fuel Combustion | 70/30 |
| Industrial Residual Fuel Oil Combustion | 70/30 |
| Industrial Natural Gas Combustion | 70/30 |
| Industrial Wood Combustion | 80/20 |
| Commercial/Institutional Coal Combustion | 20/80 |
| Commercial/Institutional Distillate Fuel Combustion | 20/80 |
| Commercial/Institutional Residual Fuel Oil Combustion | 20/80 |
| Commercial/Institutional Natural Gas Combustion | 20/80 |
| Commercial/Institutional Wood Combustion | 20/80 |
| Residential Distillate Fuel Combustion | 0/100 |
| Residential Natural Gas Combustion | 0/100 |
| Residential Wood Combustion | 0/100 |

Table 2-1

**Distribution of Major and Area Source Emissions by
Source Category (Continued)**

| Source Category | Major/Area Source Allocation^a (% Major/% Area) |
|---|--|
| Residential Coal Combustion | 0/100 |
| Mobile Sources | |
| Onroad Vehicles ^b | 0/100 |
| Non-road Vehicles ^c | 0/100 |
| Stationary Internal Combustion^d | |
| Distillate Oil - Turbines and Engines | 70/30 |
| Natural Gas - Turbines | 60/40 |
| Metals Industry | |
| Primary Aluminum Production | 100/0 |
| Primary Lead Production | 100/0 |
| Coke Ovens | 100/0 |
| Iron and Steel Foundries | 100/0 |
| Primary Copper Production ^e | 100/0 |
| Secondary Mercury Production | 50/50 |
| Secondary Copper Smelters | 25/75 |
| Secondary Lead Smelters | 80/20 |
| Secondary Aluminum Smelters | 50/50 |
| Ferroalloy Manufacturing | 0/100 |
| Miscellaneous Sources | |
| Portland Cement: Non-Hazardous Waste Kilns | 80/20 |
| Portland Cement: Hazardous Waste Kilns | 100/0 |
| Open Burning of Scrap Tires | 0/100 |
| Drum and Barrel Reclamation/Incineration | 0/100 |
| Black Liquor Combustion | 100/0 |
| Pentachlorophenol Wood Treatment | 0/100 |
| Carbon Reactivation Furnaces | 25/75 |
| Chlor-Alkali Production | 30/70 |

Table 2-1

**Distribution of Major and Area Source Emissions by
Source Category (Continued)**

| | Major/Area Source Allocation^a (% Major/% Area) |
|--|--|
| Forest Fires | 0/100 |
| Lime Manufacturing | 50/50 |
| Electrical Apparatus Manufacturing | 0/100 |
| Instrument Manufacturing | 0/100 |
| Carbon Black Production | 30/70 |
| Fluorescent Lamp Recycling | 0/100 |
| Battery Production | 0/100 |
| Geothermal Power | 0/100 |
| Lamp Breakage | 0/100 |
| General Laboratory Activities | 0/100 |
| Dental Preparation and Use | 0/100 |
| Naphthalene Production | 70/30 |
| Gasoline Distribution | 10/90 |
| Naphthalene Sulfonates Production | 70/30 |
| Phthalic Anhydride Manufacturing | 70/30 |
| Carbamate Insecticide Production | 30/70 |
| Pesticides Application ^f | 0/100 |
| Halogenated Solvents Production ^g | 100/0 |
| Bulk Plants - Aviation Gasoline | 0/100 |

Table 2-1

Distribution of Major and Area Source Emissions by Source Category (Continued)

^aThe term major, as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term area refers to any source of HAPs that is not a major source. This column provides an estimate of the distribution of major and area source facilities within each source category.

^bThe source category of onroad vehicles includes both non-leaded gasoline and diesel-powered highway vehicles.

^cThe source category of non-road vehicles includes only diesel-powered agricultural and construction equipment.

^dThe source category grouping of stationary internal combustion includes large engines (average unit size 2,500 horsepower (HP)) and turbines (average unit size 40,000 HP).

^eEPA and a number of state agencies are currently evaluating the major/area source allocation for this source category. This preliminary allocation is being used for inventory purposes only.

^fIncludes the pesticides atrazine, dimethyl tetrachloroterephthalate, simazine, picloram, chlorothalonil, propazine, and pentachloronitrobenzene.

^gIncludes the solvents 1,1,1-trichloroethane, carbon tetrachloride, ethylene dichloride, perchloroethylene, and trichloroethylene.

way that a source category is typically inventoried served as a guide for the classification (e.g., residential wood burning is always assessed as an area source). In other cases, technical analyses were conducted using actual and model plant data to determine typical facility sizes and emissions to see what percent of facilities in a category would likely trip the 10/25 ton per year HAP threshold. Lastly, in cases where no applicable data could be found to base an allocation, engineering judgement was used to assign an arbitrary allocation.

The percentages shown in Table 2-1 have no bearing or relevance to major source determinations that states may have for individual facilities as a function of any regulatory activity (e.g., New Source Performance Standard, NESHAP, New Source Review, operating permit, etc.). The major/area distributions shown in Table 2-1 are only for the purposes of this 112(c)(6) inventory analysis.

2.3 Limitations and Data Quality

As with any inventory development process, the quality of the final estimate varies considerably across categories. Given the methods used to calculate the estimates, the biggest influence on the quality of the estimate is the validity of the emission factor(s) used, in terms of absolute accuracy as well as representativeness for the processes to which it was applied. The activity data can also affect the quality of an emissions estimate, but activity data are usually easier to obtain and often have more credibility, especially when trying to determine national scale numbers. Obtaining national scale activity data that are reasonably valid was not that difficult during this inventory development process; however, there were a few categories in which the activity data were highly questionable or practically nonexistent.

Despite the problems with limited data for some source categories, the intent of the 112(c)(6) inventory process was satisfied reasonably well by the data in this report. National scale emission estimates were generated that captured, at a minimum, 90 percent of the aggregate emissions of each listed 112(c)(6) HAP. The quality of the estimates for some of the less important (in terms of emissions potential) categories can clearly be questioned due to

limits on available input information; however, taken as a whole, the data presented here provide reasonable inputs, and serve as a first step towards a 112(c)(6) prioritization process.

The most significant issue that should be noted for this inventory is that the available emission factor data were either old (>10 years) and/or very limited in terms of coverage for some source categories. This lack of data may be because the HAPs have not always been viewed as significant; therefore, little testing and emissions characterization work has been performed. This means that a very limited number of data points were available to characterize an entire category, without the benefit of knowing what the variability across the category may be. In some cases, there were no emissions data specific to a category, and surrogate data from a related source category had to be used to estimate emissions. While not optimal, this approach had to be adopted given the time and resource constraints of the 112(c)(6) inventory program. Generally, however, the source categories where this approach was used were not significant emitters of the given HAP.

The estimates that are more than likely the highest quality are those that were obtained from regulatory development programs (e.g., municipal waste combustors, primary aluminum smelters, and Portland cement kilns). These estimates have the benefit of being based on recent test data, up-to-date activity and control information, and input from informed industry experts. In some instances, these estimates represent a summation of actual source test data for most or all sources in the category. These intensive estimates are of significantly higher quality than those derived through the use of an overall emission factor.

The estimates that have come from special intensive EPA studies such as the Reports to Congress on mercury and electric utilities also represent higher quality information due to the quantity and quality of the new research done to support these programs. Estimates based on factors from recent AP-42 updates (especially those with A or B rated factors) are also relatively high quality, since the applied emission factors are more likely to reflect the increased accuracy of recent test data, as well as better source category representation.

The biggest issue with the development of the inventory estimates for 112(c)(6) categories was the lack of emissions data for categories not constituting the top 60-70 percent of total national emissions. For categories that have already been identified as relatively significant sources (60-70 percent) of a given pollutant, more emphasis has been placed by industry and regulatory agencies on performing testing and deriving good quality emission factors. Less attention and emissions quantification have historically been paid to the remaining categories, which individually may contribute little total emissions but may constitute many individual sources. The emission factor data pool for smaller combustion sources (excluding utilities and large industrial sources), some of the waste disposal sources, non-road mobile sources, secondary industrial sources, and biomass burning sources could definitely benefit from more current and expanded information. To illustrate this point, some of the only POM emissions data that could be identified for small combustion boilers dated back to the late 1970's-early 1980's.

Another issue regarding the estimation process that was clearly undesirable, but also unavoidable in the context of the 112(c)(6) inventory process, was the lack of available emissions data for some pollutant/source category combinations. As discussed further in Chapter 3, EOM data were either not available or only one or two data points were available to derive a factor for a category-wide, national emissions estimate. The overall national estimate quality implications for this type of situation are clear. Similarly, several data limitations also existed for PCB, HCB, and alkylated lead air emissions. National estimates had to be formulated for several categories from assumptions and factors with only one or two data points.

2.4 Documentation

Documentation for how the emission estimates were prepared is provided in the appendices for POM (7-PAH, 16-PAH, and EOM), dioxins/furans (TCDD, TCDF, and TCDD TEQ), and PCBs. The individual sections on mercury, HCB, and alkylated lead provide this same type of information. The documentation provided in this report is meant to identify the

key input data that were used in the calculation of national emissions. The documentation is not meant to provide an exhaustive analysis on the derivation of all the inputs. For example, an emission factor used for a national estimate may be given in an appendix, but the 10 source tests that were evaluated to obtain this factor are not presented and discussed. The goal of the provided documentation is to show the reader in a brief and concise manner where a given number came from. For example, some estimates are based on data obtained directly from work done by EPA for the development of MACT standards. These estimates may have been the product of several years of work, and may have many complex analyses and data sets behind them. In this case, the documentation provided here will attempt to identify the overall methodology and values used to calculate emissions (activity levels, factors, etc.) if available, but it will not provide all of the data that the Agency used to develop these final numbers. Adequate references are provided to allow a reader to further investigate any estimate should they so desire.

In evaluating the documentation, readers are cautioned to remember the discussion in Chapter 1.0 on how this inventory and report were compiled. The documentation, like the main report, is a summary of several different data development efforts. Estimates for different pollutants were compiled by different groups at different times and to differing levels of detail. Essentially the data exist in three sets: POM/dioxin-furan/PCBs, HCB/alkylated lead, and mercury. The available documentation maintains greatest consistency within these groupings. Because there were different parties responsible for developing emissions estimates for these three sets, it is possible that a given category was not assessed the same way, and is therefore, not documented here the same way. For example, the same category may have two different activity rates shown between different pollutants because each party obtained their data from a slightly different source or on a differing time period. The time frame and resources available for assembling this document did not allow for additional analyses to eliminate these inconsistencies. Such differences are believed to not significantly affect the estimates given in the document or the conclusions drawn from them.

2.5 References

1. Federal Register. July 16, 1992. "Initial List of Categories of Sources Under Section 112 (c)(1) of the Clean Air Act Amendments of 1990." Volume 57, No. 137. pp. 31576 - 31592.
2. U.S. Environmental Protection Agency. Documentation for Developing the Initial Source Category List. Final Report. EPA-450/3-91-030. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. 1992.
3. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, 5th Edition, AP-42, Volume I: Stationary Point and Area Sources. Research Triangle Park, North Carolina. 1995.

3.0 EMISSION ESTIMATES FOR POLYCYCLIC ORGANIC MATTER (POM)

3.1 Alternatives for Inventorying POM

The term "polycyclic organic matter," or "POM," as defined in Section 112(b) of the CAAA, includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100°C. The EPA is considering a definitional change that would exclude certain compounds (e.g., benzene/styrene polymers and biphenyls) that could technically fall under the existing POM definition, but which are not reflective of the group of compounds that the Agency believes are principally responsible for mutagenicity and carcinogenicity in humans and animals. Currently under review, the EPA may redefine POM as only including polycyclic aromatic hydrocarbons and aromatic heterocyclic compounds, with two or more fused rings, at least one of which is benzenoid in structure, which are generally formed or emitted during thermal processes including: (1) incomplete combustion; (2) pyrolysis; (3) the volatilization, distillation, or processing of fossil fuels or bitumens; or (4) the distillation or thermal processing of non-fossil fuels (Pope, 1996).

The complex mixture of POM consists of literally thousands of organic compounds. Because inventorying all POM compounds individually is impossible, surrogate approaches have been used. Most commonly, a single PAH, such as benzo-a-pyrene [B(a)P], or the sum of representative or particularly toxic PAH species, have been used as surrogates for POM (U.S. EPA, 1990; U.S. EPA, 1989). Alternatively, EPA's Office of Research and Development has been developing an approach using the EOM content of particulate matter as an appropriate measure of complex POM mixtures. EOM is believed to contain the PAH and substituted-PAH compounds that predict cancer risk better than any individual PAH or any sum of PAH species (Lewtas, 1993). However, there is some evidence that the primary health effects associated with particulate POM may be the carbon core of the particles rather than the overall organic fraction (represented as EOM). A draw back to using EOM as a

surrogate for POM is the limited amount of data available to quantify emissions. Few EOM inventories or emission factors exist at this time.

Each of these surrogate approaches for estimating POM emissions contains some inherent advantages and disadvantages. Using B(a)P alone is not thought to represent adequately either the total mass of POM emissions or the related cancer risks (Lewtas, 1993). However, a reasonable data base exists for determining B(a)P emissions from a wide variety of sources. Using a "sum-of-individual PAH species" approach, while perhaps better than using B(a)P alone, may still not represent adequately the cancer-related risks from some sources that emit significant levels of substituted-PAH compounds. However, as with B(a)P, a reasonably extensive data base exists for speciated PAH emissions. Unfortunately, there is little consistency as to what particular PAH compounds have traditionally been measured across studies and source categories. Regarding the use of EOM as a measure of POM, EPA is developing a database of EOM emissions from a variety of sources and has evaluated the toxicity of a limited number of EOM mixtures (Lewtas, 1993). To date, however, many fewer source categories have been tested for EOM than for individual PAH species.

Because there is no currently accepted method for completely characterizing POM emissions from all sources, the EPA is employing several approaches in this report: (1) the EOM approach, (2) a "sum-of-seven" approach which totals the emissions of seven PAH that are probable human carcinogens (U.S. EPA, 1993), and (3) a "sum-of-16" approach which totals the emissions of 16 PAH which are measured in EPA Method 610 (U.S. EPA, 1988). These three approaches are hereafter called the "EOM," "7-PAH," and "16-PAH" approaches, respectively. This inclusion of multiple approaches will have the effect of allowing EPA to evaluate the relative importance of POM emission sources emitters using each of the approaches, and afford EPA some flexibility to use this report if one of the approaches is deemed preferable during strategy development.

3.2 Emission Factors for 7-PAH, 16-PAH, and EOM

Table 3-1 presents the emission factors for 7-PAH, 16-PAH and EOM that were used in calculating national emissions for this study. Emission factors are presented for each of the individual source categories. For some source categories there are no available EOM emission factors and, therefore, national emissions could not be calculated in those cases. In other cases, there is no 7-PAH emission factor shown since none of the individual compounds comprising this dataset were found in the test data.

The emission factors shown in Table 3-1 were combined with national activity levels in order to calculate 1990 base year national emissions. The derivation of the EOM emission factors is described in detail in Appendix A. With the exception of utility boilers, factors for 7-PAH and 16-PAH were taken from the EPA's Locating and Estimating document for POM sources (U.S. EPA, 1996). For utility boilers, 7-PAH and 16-PAH emission factors were obtained from EPA national estimates of hazardous air pollutant emissions from utility boilers based on information collected by the Electric Power Research Institute (EPRI). These utility boiler data were used by EPA in its preparation of the Report to Congress on utility industry emissions of toxics.

The 7-PAH and 16-PAH emission factors were derived from the same source test data, so the categories are identical in terms of emission sources covered. The EOM emission factor data, however, were derived from separate source test data and in some cases the emission sources represented are not identical to those represented by the 7-PAH and 16-PAH factors. The reader should refer to Appendix A and the referenced POM Locating and Estimating Document for detailed information on the emission sources on which the factors were based (U.S. EPA, 1996).

Sections 3.2.1 and 3.2.2 provide background information on the development of the 7-PAH/16-PAH and EOM emission factor formats, respectively.

Table 3-1

**Summary Of Emission Factors for 7-PAH,^a 16-PAH,^b
and EOM By Source Category Used to Estimate 1990 Emissions**

| Source Category | 7-PAH Emission Factor ^c | 16-PAH Emission Factor ^d | EOM Emission Factor |
|--|--|--|--|
| STATIONARY EXTERNAL COMBUSTION | | | |
| Residential Heating | | | |
| Residential Wood Combustion | 0.034 lb/ton of wood burned | 0.524 lb/ton of wood burned | 13.96 lb/ton of wood burned |
| Residential Natural Gas Combustion | 0.0373 lb/trillion Btu of heat input | 2.37 lb/trillion Btu of heat input | 1,921 lb/trillion Btu of heat input |
| Residential Distillate Oil Combustion | 5.63E-04 lb/1,000 gal of fuel consumed | 6.97E-03 lb/1,000 gal of fuel consumed | 0.485 lb/1,000 gal of fuel consumed |
| Residential Coal Combustion (bituminous and lignite) | 0.0335 lb/ton of coal consumed | 0.108 lb/ton of coal consumed | ND ^e |
| Residential Coal Combustion (anthracite) | 1.41E-04 lb/ton of coal consumed | 6.18E-04 lb/ton of coal consumed | ND |
| Utility, Industrial, and Commercial Boilers | | | |
| Utility Natural Gas Combustion | ND | 0.7233 lb/trillion Btu of heat input | 740 lb/trillion Btu of heat input |
| Utility Coal Combustion | 0.0241 lb/trillion Btu of heat input | 0.8747 lb/trillion Btu of heat input | 4,777 lb/trillion Btu of heat input |
| Utility Residual Oil Combustion | 0.0831 lb/trillion Btu of heat input | 0.9251 lb/trillion Btu of heat input | 930 lb/trillion Btu of heat input |
| Industrial Wood/Wood Residue Combustion | 5.90E-05 lb/ton of wood burned | 3.36E-03 lb/ton of wood burned | 2.16 lb/ton of wood burned |
| Industrial Natural Gas Combustion | ND | 5.56E-06 lb/million cubic feet of natural gas consumed | 0.24 lb/million cubic feet of natural gas consumed |
| Industrial Coal Consumption | 5.36E-05 lb/ton of coal consumed | 2.72E-03 lb/ton of coal consumed | 4.2E-02 lb/ton of coal consumed |
| Industrial Residual Oil Combustion | 1.60E-07 lb/million Btu of heat input | 2.15E-04 lb/million Btu of heat input | 4.66E-04 lb/million Btu of heat input |
| Industrial Distillate Oil Combustion | 5.96E-09 lb/million Btu of heat input | 5.00E-05 lb/million Btu of heat input | 3.50E-03 lb/million Btu of heat input |

Table 3-1

**Summary Of Emission Factors for 7-PAH,^a 16-PAH,^b
and EOM By Source Category Used to Estimate 1990 Emissions (Continued)**

| Source Category | 7-PAH Emission Factor ^c | 16-PAH Emission Factor ^d | EOM Emission Factor |
|---|--|--|--|
| Industrial Waste Oil Combustion | 4.53E-03 lb/1,000 gallons of waste oil consumed | 0.0265 lb/1,000 gallons of waste oil consumed | ND |
| Commercial Wood/Wood Residue Combustion | 7.43E-05 lb/million Btu of heat input | 2.63E-03 lb/million Btu of heat input | 0.143 lb/million Btu of heat input |
| Commercial Natural Gas Combustion | ND | 2.54E-05 lb/million cubic feet of natural gas consumed | 1.44 lb/million cubic feet of natural gas consumed |
| Commercial Coal Combustion (bituminous and lignite) | 0.0200 lb/ton of coal consumed | 0.0771 lb/ton of coal consumed | 1.35 lb/ton of coal consumed |
| Commercial Coal Combustion (anthracite) | ND | 0.137 lb/ton of coal consumed | ND |
| Commercial Residual Oil Combustion | 1.60E-07 lb/million Btu of heat input | 2.14E-04 lb/million Btu of heat input | 1.86E-03 lb/million Btu of heat input |
| Commercial Distillate Oil Combustion | 5.96E-09 lb/million Btu of heat input | 5.00E-05 lb/million Btu of heat input | 3.96E-03 lb/million Btu of heat input |
| STATIONARY INTERNAL COMBUSTION | | | |
| Industrial IC Engines | | | |
| Industrial IC Engines - Diesel | 3.36E-06 lb/million Btu of heat input | 1.89E-04 lb/million Btu of heat input | 7.85E-02 lb/million Btu of heat input |
| Industrial IC Engines - Natural Gas | 2.75E-03 lb/million cubic feet of natural gas consumed | 0.127 lb/million cubic feet of natural gas consumed | ND |
| Turbines | | | |
| Turbines - Diesel | ND | 1.03E-07 lb/million Btu of heat input | 1.24E-02 lb/million Btu of heat input |
| Turbines - Natural Gas | ND | 4.90E-05 lb/million Btu of heat input | 2.63E-03 lb/MMBtu of heat input |

Table 3-1

**Summary Of Emission Factors for 7-PAH,^a 16-PAH,^b
and EOM By Source Category Used to Estimate 1990 Emissions (Continued)**

| Source Category | 7-PAH Emission Factor ^c | 16-PAH Emission Factor ^d | EOM Emission Factor |
|---|---|--|--------------------------------------|
| WASTE INCINERATION | | | |
| Municipal Waste Combustion | ND | 6.06E-06 lb/ton of waste incinerated | 1.14E-02 lb/ton of waste incinerated |
| Sewage Sludge Incineration | 1.822E-05 lb/ton of sludge incinerated | 3.44E-03 lb/ton of sludge incinerated | ND |
| Medical Waste Incineration | ND | 9.22E-04 lb/ton of waste incinerated | 1.78E-02 lb/ton of waste incinerated |
| Other Biological Waste Incineration | ND | ND | 1.78E-02 lb/ton of waste incinerated |
| Hazardous Waste Incineration | 2.91E-05 lb/ton of hazardous waste incinerated | 2.44E-04 lb/ton of hazardous waste incinerated | ND |
| Drum and Barrel Reclamation | 5.53E-07 lb/1,000 barrels reclaimed | 3.56E-05 lb/1,000 barrels reclaimed | ND |
| Scrap Tire Incineration | 1.68E-03 lb/1 million tires incinerated | 0.40 lb/1 million tires incinerated | ND |
| Landfill Flares | 3.08E-08 lb/million Btu of heat input | 1.30E-05 lb/million Btu of heat input | ND |
| METALS INDUSTRY | | | |
| Primary Aluminum Production | 0.064 lb/ton of primary aluminum produced | 0.30 lb/ton of primary aluminum produced | ^f |
| Sintering in the Iron and Steel Foundries | ND | ND | ND |
| Ferroalloy Manufacturing | 0.000824 lb/ton wood consumed 0.002324 lb/ton coal consumed 0.000232 lb/ton coke consumed | 0.00175 lb/ton wood consumed 0.00503 lb/ton coal consumed 0.00050 lb/ton coke consumed | ND |
| Iron and Steel Foundries ^g | 2.07E-05 lb/ton of metal produced | 5.82E-03 lb/ton of metal produced | ND |

Table 3-1

**Summary Of Emission Factors for 7-PAH,^a 16-PAH,^b
and EOM By Source Category Used to Estimate 1990 Emissions (Continued)**

| Source Category | 7-PAH Emission Factor ^c | 16-PAH Emission Factor ^d | EOM Emission Factor |
|---|--|--|---|
| Secondary Lead Smelting | | | |
| Blast Furnace | ND | 0.0199 lb/ton lead produced | ND |
| Rotary and Blast/Reverberatory | 3.7E-05 lb/ton of lead produced | 5.1E-05 lb/ton of lead produced | ND |
| PETROLEUM REFINING | | | |
| Catalytic Cracking Units | 1.66E-05 lb/barrel of oil charged | 3.16E-04 lb/barrel of oil charged | ND |
| ASPHALT PRODUCTION | | | |
| Asphalt Roofing Production | 1.1E-04 lb/ton of asphalt roofing produced | 2.86E-03 lb/ton of asphalt roofing produced | ND |
| Asphalt Hot-mix Production | 3.90E-07 lb/ton of hot-mix asphalt produced | 1.82E-04 lb/ton of hot-mix asphalt produced | ND |
| COKE PRODUCTION | | | |
| Coke Ovens: Charging, Topside, and Door Leaks | 1.1E-03 lb/ton of coal charged | 8.2E-03 lb/ton of coal charged | 4.7E-02 lb/ton of coal charged ^h |
| Coke Ovens: Pushing, Quenching, and Battery Stacks | 3.09E-03 lb/ton of coal charged | 0.053 lb/ton of coal charged | ND |
| PORTLAND CEMENT MANUFACTURING | | | |
| Portland Cement: Non-Hazardous Waste Kilns | 8.21E-05 lb/ton clinker produced | 1.51E-03 lb/ton clinker produced | ND |
| Portland Cement: Hazardous Waste Kilns | 2.52E-04 lb/ton clinker produced | 1.53E-03 lb/ton clinker produced | ND |
| PULP AND PAPER INDUSTRY | | | |
| Kraft Recovery Furnaces | 1.23E-04 lb/air-dry ton of pulp produced | 2.13E-02 lb/air-dry ton of pulp produced | ND |

Table 3-1

**Summary Of Emission Factors for 7-PAH,^a 16-PAH,^b
and EOM By Source Category Used to Estimate 1990 Emissions (Continued)**

| Source Category | 7-PAH Emission Factor ^c | 16-PAH Emission Factor ^d | EOM Emission Factor |
|----------------------------------|--|--|--------------------------------------|
| Lime Kilns | 3.3E-06 lb/million Btu of heat input | 2.46E-03 lb/million Btu of heat input | ND |
| Sulfite Recovery Furnaces | ND | 4.30E-03 lb/air-dry ton of pulp produced | ND |
| OPEN BURNING | | | |
| Wildfires and Prescribed Burning | 0.020 lb/ton of biomass burned | 0.053 lb/ton of biomass burned | ND |
| Open Burning of Scrap Tires | 1,400 lb/1,000 tons of tire burned | 7,850 lb/1,000 tons of tire burned | ND |
| MOBILE SOURCES | | | |
| Onroad Vehicles | 1.75E-08 lb/mile | 4.34E-08 lb/mile | 5.2E-05 lb/vehicle miles of travel |
| Aircraft | 1.09E-05 lb/landing and take-off (LTO) | 3.06E-04 lb/LTO | ND |
| Locomotives | ND | ND | ND |
| Marine Vessels | ND | ND | ND |
| Non-road Vehicles and Equipment | ND | ND | 8.4E-03 lb/gallon of diesel consumed |
| MISCELLANEOUS SOURCES | | | |
| Carbon Black Manufacturing | 5.25E-04 lb/ton of carbon black produced | 5.04E-03 lb/ton of carbon black produced | ND |
| Wood Treatment/Wood Preserving | ND | 1.94E-03 lb/cubic feet of wood treated with creosote | ND |
| Cigarette Smoke | 2.08E-09 lb/cigarette consumed | 1.38E-08 lb/cigarette consumed | ND |
| Crematories | 7.07E-11 lb/body cremated | 4.16E-08 lb/body cremated | ND |
| Gasoline Distribution | ND | i | ND |
| Carbon Fiber Manufacturing | ND | ND | ND |

Table 3-1

**Summary Of Emission Factors for 7-PAH,^a 16-PAH,^b
and EOM By Source Category Used to Estimate 1990 Emissions (Continued)**

| Source Category | 7-PAH Emission Factor ^c | 16-PAH Emission Factor ^d | EOM Emission Factor |
|---------------------------------------|---------------------------------------|--|---------------------|
| NAPHTHALENE PRODUCTION AND USE | | | |
| Naphthalene Production | NA ^j | 0.523 lb/ton of naphthalene produced 0.0024 lb/ton of coke produced | ND |
| Phthalic Anhydride Production | NA | 0.34 lb/1000 lb naphthalene processed | ND |
| Carbamate Insecticides Production | NA | 0.34 lb/1000 lb naphthalene processed | ND |
| Naphthalene Sulfonates Production | NA | 0.34 lb/1000 lb naphthalene processed | ND |
| Miscellaneous Uses | NA | 0.34 lb/1000 lb naphthalene processed | ND |

^a7-PAH subset includes benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

^b16-PAH subset includes acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene.

^cAll 7-PAH are not included in the 7-PAH factor for every source category; in some cases, there is not a complete set of factors for all 7-PAH since the available test data did not report or sample for a specific PAH compound(s). Refer to Appendix B for a listing of the specific compounds included in the 7-PAH emission factor for a particular source category.

^dAll 16-PAH are not included in the 16-PAH factor for every source category; in some cases, there is not a complete set of factors for all 16-PAH since the available test data did not report or sample for a specific PAH compound(s). Refer to Appendix B for a listing of the specific compounds included in the 16-PAH emission factor for a particular source category.

^e"ND" indicates that there were no emission factor data available.

^fThe EOM estimate was not developed using overall activity data and an emission factor, but is based on plant-specific emissions.

^gEmissions vary by type of furnace and quality of scrap metal.

^hThe EOM emission factor for coke ovens includes charging operations, leaking doors, charging lids, and oven offtakes.

ⁱNot based on an emission factor, the estimate was produced by the Gasoline Distribution NESHAP process.
See Appendix B for details.

^jNot applicable.

3.2.1 7-PAH and 16-PAH Emission Factor Development

The EPA has identified a subset of 16 PAH compounds that have been targeted as part of a suggested procedure for measuring these type of compounds (U.S. EPA, 1988). The PAHs included in this measurement procedure are:

| | |
|----------------|-------------------------|
| Naphthalene | Benzo(ghi)perylene |
| Acenaphthene | Benz(a)anthracene* |
| Acenaphthylene | Chrysene* |
| Fluorene | Benzo(b)fluoranthene* |
| Phenanthrene | Benzo(k)fluoranthene* |
| Anthracene | Benzo(a)pyrene* |
| Fluoranthene | Dibenz(a,h)anthracene* |
| Pyrene | Indeno(1,2,3-cd)pyrene* |

The sum of these 16-PAH constitute the "16-PAH" quantity referred to in this document. The seven compounds with asterisks (*) next to them indicate compounds that the International Agency for Research on Cancer (IARC) has determined to be animal carcinogens. The sum of these seven compounds represents the "7-PAH" emission subset that is used in this inventory.

The 16-PAHs listed above are commonly reported in emissions source testing because they are the targeted compounds in the standard EPA and state analytical methods. These standard analytical methods are the EPA's Modified Method 5, a test procedure to measure semi-volatile organic compounds, and the California Air Resources Board (CARB) Method 429, a sampling and analytical method to determine PAH emissions from stationary sources. Sources that have been tested with these methods include fuel combustion, coke production, motor vehicle emissions, petroleum refining processes, waste incineration, asphalt production, and natural emissions sources such as forest fires.

The majority of the existing research on POM emissions has been compiled for individual PAH compounds listed above or for some grouping of these compounds. This grouping is often referred to in the literature as "total PAH," "total PNA," or inaccurately as "total POM." There is no consistent definition of the term "total PAH" or "total POM" as used in previous inventory efforts. Within one study, the definition will refer to only 4 PAH compounds for one category of sources and 13 PAH compounds for another source. While the testing methods on which the data are based are the same in most cases, different compounds are targeted for reporting purposes.

In compiling the 7-PAH and 16-PAH emission factors shown in Table 3-1, there was not always a complete set of emission factors for the 7-PAH and 16-PAH subsets. In some cases, certain PAH compounds were not measured in the original emission source tests and therefore are not represented in the emission factor. The reader should refer to Appendix B for a listing of the individual PAH compounds that are included in the 7-PAH and 16-PAH emission factors for each source category.

3.2.2 EOM Emission Factor Development

Extractable organic matter, or EOM, is a gravimetric-based measurement of solvent EOM which includes all of the multi-ring POM compounds. EOM is reported as a total mass with no individual compounds speciated. EOM is generally the organic fraction of particulate and/or semi-volatile matter collected during sampling.

The EOM emission factors used in this inventory were developed from either of two specific sampling methods: the dilution tunnel technique or the Source Assessment Sampling System (SASS). The dilution tunnel method is designed to collect total particulate and particulate bound organic material at conditions which approximate the ambient environment. The SASS is designed to collect particulate and nonparticulate organic and inorganic materials at source conditions.

The dilution tunnel technique has been used by the EPA's Air Pollution Prevention and Control Division (APPCD) to measure the EOM emissions from various sources. The known carcinogenic PAH compounds, and the substituted PAHs that constitute POM, are a part of the EOM based estimates, including methylated PAH, nitrated PAH, oxidized PAH, and a variety of other POM compounds that are being studied as potential animal and human carcinogens.

In order to better account for the large number of compounds that may contribute to the overall risk estimate for POM emissions from a source, the current health effects research conducted by the EPA's National Health and Environmental Effects Research Laboratory (NHEERL) has focused on measurements of EOM emissions (Lewtas, 1993). In these studies, the EOM being measured is condensible and usually particle associated. Urban area source data collected for this research is based on EOM from particle source emissions collected by a dilution method in which the condensible organic matter containing POM is absorbed to the particulate matter. Dilution sampling was also used for mobile source emission tests (i.e., diesel and gasoline internal combustion emissions). Source samples have been collected as the condensed fraction from process streams (i.e., coke ovens and roofing tar) or as diluted samples collected on filters and selected sorbents (i.e., wood stoves, residential distillate oil).

The EOM emissions data that has been collected as part of the research described above have been used in the comparative potency method to develop cancer unit risk estimates. It should be noted that comparative potency is not an official EPA unit risk estimate. This approach, and the risk estimates derived from it, have been used by the EPA's Office of Air Quality Planning and Standards (OAQPS) in their current cancer risk assessment reports and are being considered for insertion into the Integrated Risk Information System (IRIS) (Lewtas, 1993). The Office of Mobile Sources has also used comparative potency in the Motor Vehicle-Related Air Toxic Study, but has characterized the estimate as highly uncertain.

The SASS was the sampling technique used to measure gravimetric organics in the EPA's series of environmental assessments performed on various source categories in the late 1970's and early 1980's. Extractable organic material from environmental assessment samples was quantified in the following way: gravimetric organics, also known as organics >C16, were determined by allowing a measured aliquot of the total organic extract to evaporate to dryness, leaving only the condensible organic material behind. Laboratory studies determined that the range of material in these samples included organic compounds with a boiling point above the normal 16 carbon compound, hexadecane, hence the name >C16. This sample preparation approach was used by the EPA's NHEERL in early studies of animal carcinogenic potency. This approach forms the basis for the mass measurement technique used by NHEERL for EOM from complex environmental samples. Therefore, EOM as defined by NHEERL and as quantified in the SASS analysis are identical. The EOM measurement only differs between these two techniques by the way the materials were obtained from the source.

3.3 Source Category Inclusion

Included in this inventory are most of the known, significant contributors to PAH emissions based on available test data, such as external combustion sources, primary aluminum production, and onroad vehicles. These sources were identified through an extensive literature search, based primarily on identifying sources of any of the compounds in the 7-PAH or 16-PAH subset. However, there are some suspected sources for which there is relatively little or no emissions test data available in order to estimate national emissions. For example, non-road mobile sources such as agricultural, construction, and industrial equipment and vehicles are all suspected sources of PAH because they have internal combustion engines and there is an EOM emission factor; however, there is no adequate accumulation of test data for these sources from which to develop emission factors.

Based on available test data, POM emissions can be released from hazardous waste disposal by incineration. POM estimates are quantified in this document for dedicated

hazardous waste incinerators and Portland cement kilns burning hazardous waste as a supplemental fuel. Based on the data from these sources, it is suspected that POM emissions would also be released from other hazardous waste disposal processes such as light weight aggregate kilns (LWAKS) and other boilers and industrial furnaces (BIFs). POM emission estimates could not be determined in this inventory for LWAKs and other BIFs (e.g., large boilers, smelting furnaces) due to either a lack of source-specified emission factors or activity data. EPA's Office of Solid Waste plans to begin studying these types of waste disposal sources in greater depth in the near future, and more data from which to quantify POM emissions may be generated at that time.

The EOM source categories were identified based on an in-depth review of available literature sources and on previous national inventories for POM emissions. Many of the known POM source categories are also EOM source categories; however, there is only a limited number of sources for which EOM emissions data have been collected. National emissions estimates were developed for all source categories where EOM emission factors were available. Table 3-2 identifies the categories for which national emissions were determined.

The following categories were identified as potentially significant sources of EOM emissions (based on known POM emission sources) for which sufficient emission factor data were not available to develop national emissions:

- Iron and Steel Foundries;
- Secondary Lead Smelting;
- Asphalt Roofing Manufacture;
- Asphalt Hot-mix Production;
- Pulp and Paper Production;

Table 3-2
7-PAH, 16-PAH, And EOM 1990 Base Year National Emissions Estimates
by Source Category

| Source Category | Number of U.S. Facilities | 7-PAH National Emissions ^a (tons/yr) | 16-PAH National Emissions ^b (tons/yr) | EOM National Emissions (tons/yr) |
|---|-----------------------------------|--|---|-------------------------------------|
| STATIONARY EXTERNAL COMBUSTION | | | | |
| Residential Heating: | | | | |
| Wood Combustion | 22.5 x 10 ⁶ households | 572 | 8,855 | 235,881 |
| Natural Gas Combustion | ^c | 0.08 | 5.10 | 4,142 |
| Distillate Oil Combustion | 10.1 x 10 ⁶ households | 1.70 | 21.0 | 1,465 |
| Coal Combustion | unknown | 31.8 | 103 | ND ^d |
| Utility Boilers: | | | | |
| Utility Natural Gas Combustion | 545 | ND | 0.69 | 1,004 |
| Utility Coal Combustion (bituminous) | 1,201 | 0.21 | 7.54 | 38,627 |
| Utility Residual Oil Combustion | 545 | 0.05 | 0.57 | 531 |
| Industrial Boilers: | | | | |
| Industrial Wood/Wood Residue Combustion | 500,000 | | | |
| Industrial Wood/Wood Residue Combustion | 45,150 | 2.67 | 152 | 97,848 |
| Industrial Natural Gas Combustion | ^c | ND | 0.02 | 928 |
| Industrial Coal Combustion | ^c | 3.09 | 157 | 2,412 |
| Industrial Residual Oil Combustion | 6,000 | 0.03 | 44.7 | 97 |
| Industrial Waste Oil Combustion | ^c | 1.34 | 7.82 | ND |
| Industrial Distillate Oil Combustion | ^c | 7.33E-04 | 6.15 | 397 |

Table 3-2
7-PAH, 16-PAH, And EOM 1990 Base Year National Emissions Estimates
by Source Category (Continued)

| Source Category | Number of U.S. Facilities | 7-PAH National Emissions ^a (tons/yr) | 16-PAH National Emissions ^b (tons/yr) | EOM National Emissions (tons/yr) |
|---|---------------------------|--|---|-------------------------------------|
| Commercial Boilers: | 1.3 x 10 ⁶ | | | |
| Commercial Wood/Wood Residue Combustion | ^c | 1.01 | 35.8 | 1,946 |
| Commercial Natural Gas Combustion | ^c | ND | 0.03 | 1,921 |
| Commercial Coal Combustion (bituminous and lignite) | ^c | 36.0 | 139 | 2,744 |
| Commercial Coal Combustion (anthracite) | ^c | ND | 33.7 | ND |
| Commercial Distillate Oil Combustion | ^c | 1.57E-03 | 13.2 | 965 |
| Commercial Residual Oil Combustion | ^c | 0.03 | 40.1 | 350 |
| STATIONARY INTERNAL COMBUSTION | | | | |
| Industrial IC Engines: | | | | |
| Diesel | ^c | 0.0893 | 5.02 | 1,929 |
| Natural Gas | ^c | 1.03 | 47.6 | ND |
| Turbines: | | | | |
| Diesel | ^c | ND | 0.0155 | 1,731 |
| Natural Gas | ^c | ND | 13.8 | 739 |
| WASTE INCINERATION | | | | |
| Municipal Waste Combustion | 158 | ND | 0.099 | 182 |
| Sewage Sludge Incineration | 174 | 8.67E-03 | 1.64 | ND |
| Medical Waste Incineration | 3,400 | ND | 0.80 | 15 |
| Hazardous Waste Incineration ^e | 150 | 0.02 | 0.17 | ND |

Table 3-2

**7-PAH, 16-PAH, And EOM 1990 Base Year National Emissions Estimates
by Source Category (Continued)**

| Source Category | Number of U.S. Facilities | 7-PAH National Emissions ^a (tons/yr) | 16-PAH National Emissions ^b (tons/yr) | EOM National Emissions (tons/yr) |
|--|---------------------------|--|---|-------------------------------------|
| Drum and Barrel Reclamation | 12 | 1.27E-06 | 8.19E-05 | ND |
| Scrap Tire Incineration | 18 | 2.17E-05 | 5.18E-03 | ND |
| Landfill Flares | | 1.05E-03 | 0.445 | ND |
| Other Biological | 1,700 | ND | ND | 1 |
| METALS INDUSTRY | | | | |
| Primary Aluminum Production | 6 | 141 ^f | 662 ^f | 3,876 ^f |
| Ferroalloy Manufacturing | 27 | 0.26 | 0.56 | ND |
| Iron and Steel Foundries | 1,100 | 0.11 | 29.7 | ND |
| Secondary Lead Smelting | 22 | 0.019 | 3.03 | ND |
| PETROLEUM REFINING | | | | |
| Catalytic Cracking Unit | 192 | 16.4 | 313 | ND |
| ASPHALT PRODUCTION | | | | |
| Asphalt Roofing Production | 98 | 1.68 | 43.6 | ND |
| Asphalt Hot-Mix Production | 3,600 | 0.094 | 43.7 | ND |
| COKE PRODUCTION | | | | |
| Coke Ovens: Charging, Topside, and Door Leaks | 29 | 21.2 | 158 | 679 ^g |
| Coke Ovens: Pushing, Quenching, and Battery Stacks | 29 | 30.1 | 516.6 | ND |

Table 3-2
7-PAH, 16-PAH, And EOM 1990 Base Year National Emissions Estimates
by Source Category (Continued)

| Source Category | Number of U.S. Facilities | 7-PAH National Emissions ^a (tons/yr) | 16-PAH National Emissions ^b (tons/yr) | EOM National Emissions (tons/yr) |
|---|--------------------------------|--|---|-------------------------------------|
| PORTLAND CEMENT MANUFACTURING | | | | |
| Portland Cement: Non-Hazardous Waste Kilns | 90 | 2.78 | 51.0 | ND |
| Portland Cement: Hazardous Waste Kilns | 20 | 4.61 | 28.0 | ND |
| PULP AND PAPER INDUSTRY | | | | |
| Kraft Recovery Furnaces | 149 | 3.74 | 649 | ND |
| Lime Kilns | 149 | 0.25 | 183 | ND |
| Sulfite Recovery Furnaces | 16 | ND | 6.17 | ND |
| OPEN BURNING | | | | |
| Wildfires and Prescribed Burning | Not applicable | 964 | 2,540 | ND |
| Open Burning of Scrap Tires | Not applicable | 307 | 1,720 | ND |
| MOBILE SOURCES | | | | |
| Onroad Vehicles | 165 x 10 ⁶ vehicles | 18.81 | 46.63 | 56,157 |
| Aircraft | ^c | 0.07 | 1.87 | ND |
| Locomotives | ^c | ND | ND | ND |
| Marine Vessels | ^c | ND | ND | ND |
| Non-road Vehicles and Equipment | ^c | ND | ND | 25,116 |
| MISCELLANEOUS SOURCES | | | | |
| Carbon Black Manufacturing | 24 | 0.45 | 4.33 | ND |

Table 3-2
7-PAH, 16-PAH, And EOM 1990 Base Year National Emissions Estimates
by Source Category (Continued)

| Source Category | Number of U.S. Facilities | 7-PAH National Emissions ^a (tons/yr) | 16-PAH National Emissions ^b (tons/yr) | EOM National Emissions (tons/yr) |
|--|---------------------------|--|---|-------------------------------------|
| Wood Treatment/Wood Preserving with creosote | 72 ^h | ND | 457 | ND |
| Cigarette Smoke | Not applicable | 0.52 | 3.45 | ND |
| Crematories | 395 | 1.42E-08 | 8.33E-06 | ND |
| Gasoline Distribution | >400,000 | ND | 727 | ND |
| Carbon Fiber Manufacturing | 3 | NA ⁱ | NA | ND |
| NAPHTHALENE PRODUCTION AND USE | | | | |
| Naphthalene Production | 6 | ND | 64.6 | ND |
| Phthalic Anhydride Production | 1 | ND | 26.2 | ND |
| Carbamate Insecticides Production | 1 | ND | 4.08 | ND |
| Naphthalene Sulfonates Production | 8 | ND | 6.53 | ND |
| Miscellaneous Uses - Naphthalene | ^c | ND | 1.22 | ND |

^a7-PAH subset includes benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(d)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. All 7-PAH are not included in the 7-PAH emissions for every source category; in some cases, there is not a complete set of emission factors for all 7-PAH since the available test data did not report or sample for a specific PAH compound(s). Refer to Appendix B for a listing of the specific compounds included in the 7-PAH emission factor for a particular source category.

^b16-PAH subset includes acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. All 16-PAH are not included in the 16-PAH emissions for every source category; in some cases, there is not a complete set of emission factors for all 16-PAH since the available test data did not report or sample for a specific PAH compound(s). Refer to Appendix B for a listing of the specific compounds included in the 16-PAH emission factor for a particular source category.

^cIndicates an estimate of the number of facilities in the U.S. was not available.

Table 3-2

7-PAH, 16-PAH, And EOM 1990 Base Year National Emissions Estimates by Source Category (Continued)

^d"ND" indicates that there were no emission factor data available, therefore, a national emission estimate was not calculated in these cases.

^eEmissions estimate for this category represents emissions from dedicated hazardous waste incinerators. It does not include BIFs. A separate estimate is provided for Portland cement kilns burning hazardous waste. No estimates, are available for LWAKs and other BIFs.

^fThe estimated 1990 emissions will be reduced by 50 percent after the proposed MACT standard for primary aluminum production is implemented.

^gEOM emission estimate includes charging operations, leaking doors, charging lids, and oven offtakes.

^hNumber of facilities that treat wood with creosote (57 use creosote exclusively, 15 use both creosote and pentachlorophenol).

ⁱNot available.

- Carbon Black Manufacturing;
- Wood Treatment and Preserving;
- Charcoal Manufacturing;
- Hazardous Waste Incineration;
- Petroleum Refining; and
- Locomotives, Aircraft, and Other Non-road Vehicles (excluding agriculture and construction equipment which are accounted for in this inventory).

Of the above listed categories, iron and steel foundries and petroleum refineries are likely to be significant sources of EOM emissions based on the air emissions for individual POM compounds reported in available source data and references.

3.4 Detailed Emissions Summary

3.4.1 National Emissions

Table 3-2 presents the 1990 base year 7-PAH, 16-PAH, and EOM national emissions by source category. Appendix A summarizes the factors and methodology used for the EOM national emissions calculations. Appendix B documents the national emissions calculations for 7-PAH and 16-PAH. The documentation in Appendices A and B provide information on the data sources on which the emission factors were based for each individual source category.

Current emissions for several of these source categories (e.g., MWC, cement kilns, and MWI) are significantly below the 1990 levels shown here due to the development and application of various MACT standards. For these source categories, the 1990 estimates are not representative of the reduced contributions these categories are making to current national emission levels.

Due to the lack of adequate emission factor data, there are many source categories listed in Table 3-2 for which EOM national emissions could not be calculated. Section 3.3 provides a listing of suspected EOM sources for which emissions could not be calculated for this inventory due to the lack of emission factor data.

The reader should be aware that the emission sources for each source category, on which the emission factor data are based, are different between the PAH subsets and EOM. The 7-PAH and 16-PAH emission estimates are based on the same emission source test data (i.e., the emission factors were developed from testing done on the same unit at the same time); the EOM emissions, however, are based on test data conducted separately and the emission sources are not always identical (e.g., in terms of unit configuration or control devices in place) to the ones on which the 7-PAH and 16-PAH emissions are based. This inconsistency should be noted in making any comparisons of the relative size of emissions from source categories between the PAH subsets and EOM.

Figures 3-1, 3-2, and 3-3 show the breakdown of 1990 base year national emissions for 7-PAH, 16-PAH, and EOM, respectively. Each figure shows the estimated annual emissions in tons per year and the percentage contribution to national emissions for the most significant source categories.

Overall, the reader should be aware of the inherent differences between the three POM emission formats when studying the emissions breakdown shown in Figures 3-1, 3-2, and 3-3. While there are similar trends for some source category contributions (e.g., residential wood combustion is clearly a significant category for all three formats), each of the three formats represent uniquely different quantities. The EOM emissions, for example, are much higher for most source categories because the EOM measurement method includes many more PAH compounds than the 7-PAH and 16-PAH subsets. Other differences are related to the characteristics of the emission sources on which the emission calculations were based. For example, the EOM emission factor for onroad vehicles is based on 1970 and early 1980 model year vehicles, whereas the 7-PAH and 16-PAH emission factors represent much more

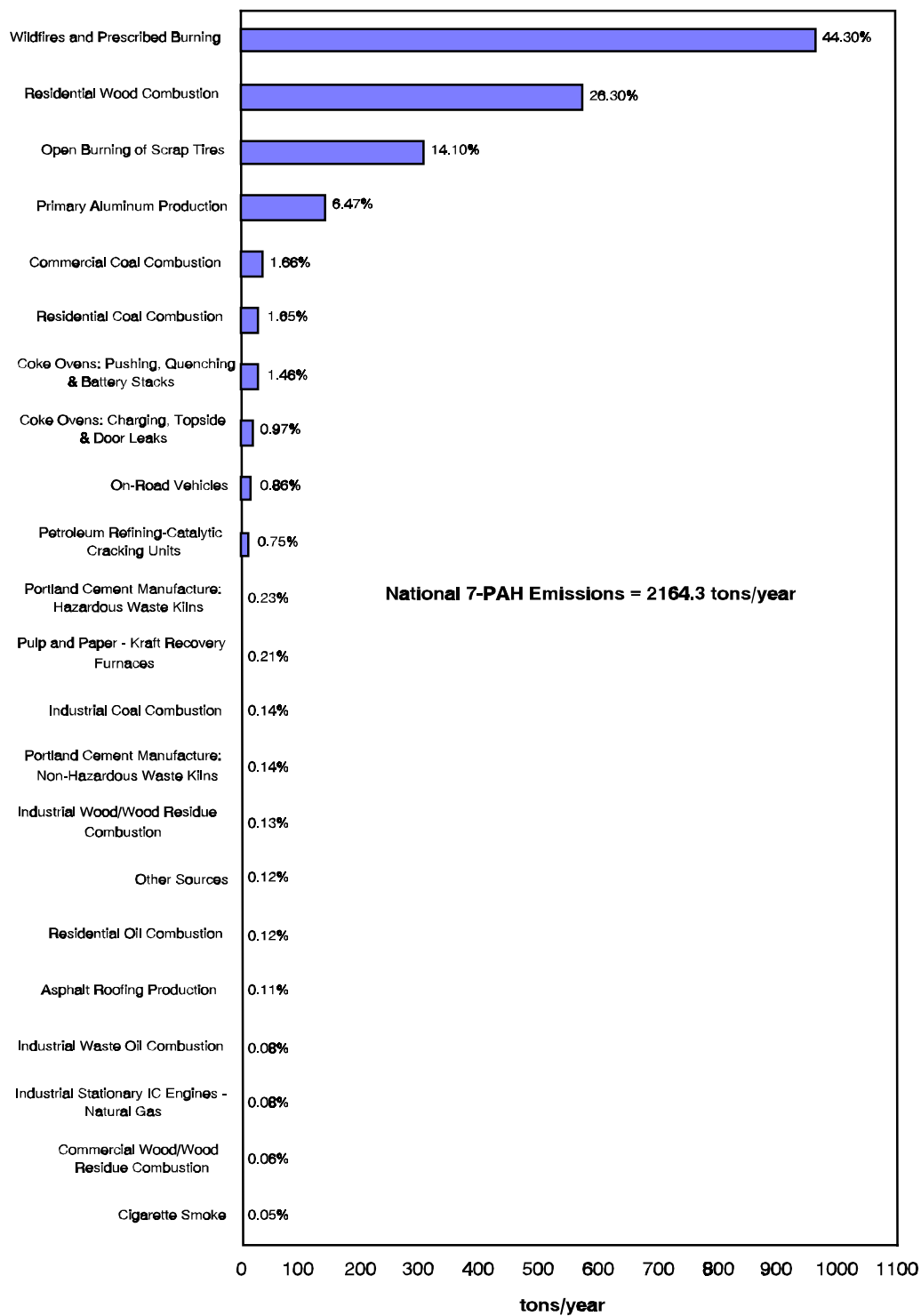


Figure 3-1. Percentage Contribution to 1990 National 7-PAH Emissions by Source Category

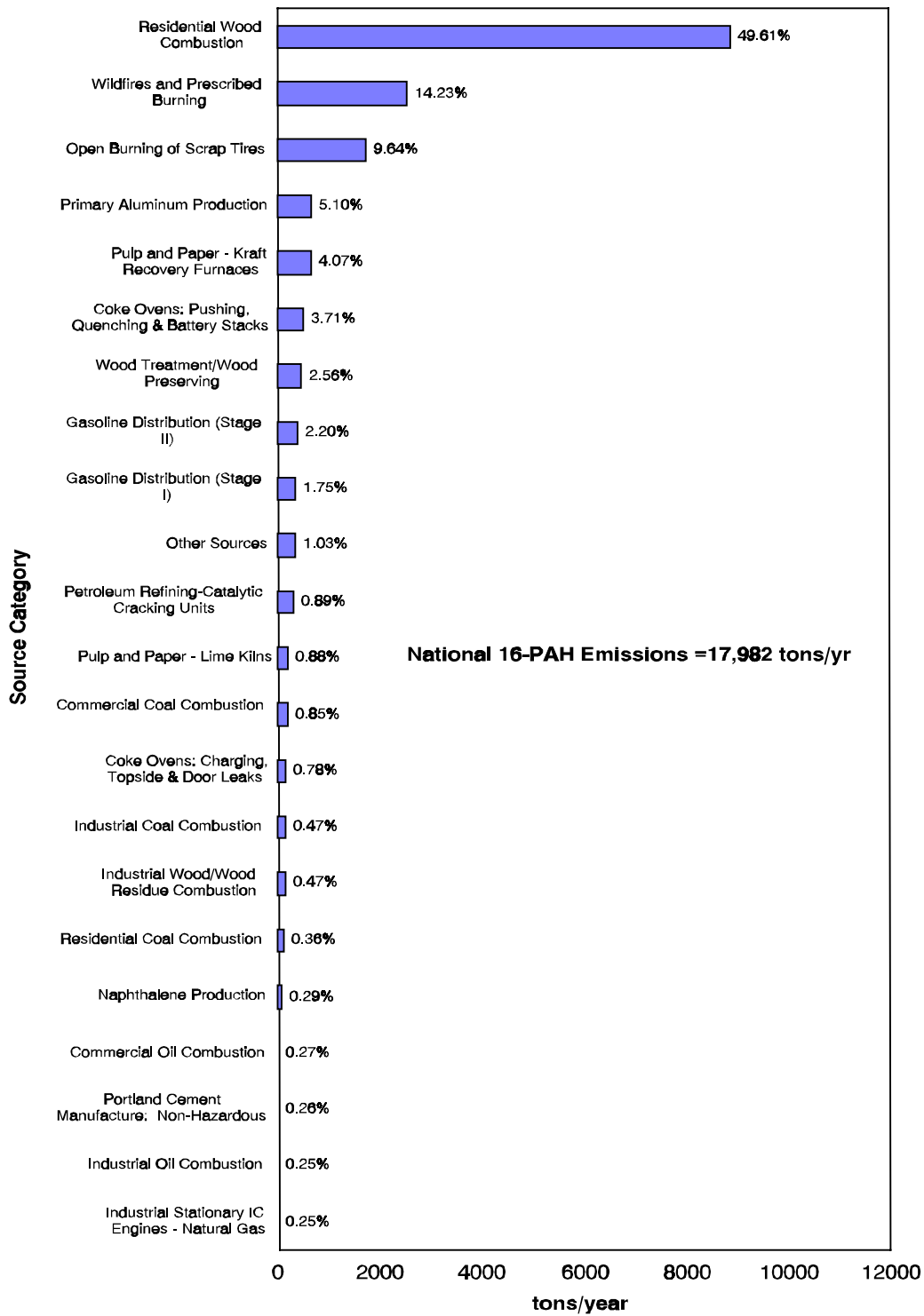


Figure 3-2. Percentage Contribution to 1990 National 16-PAH Emissions by Source Category

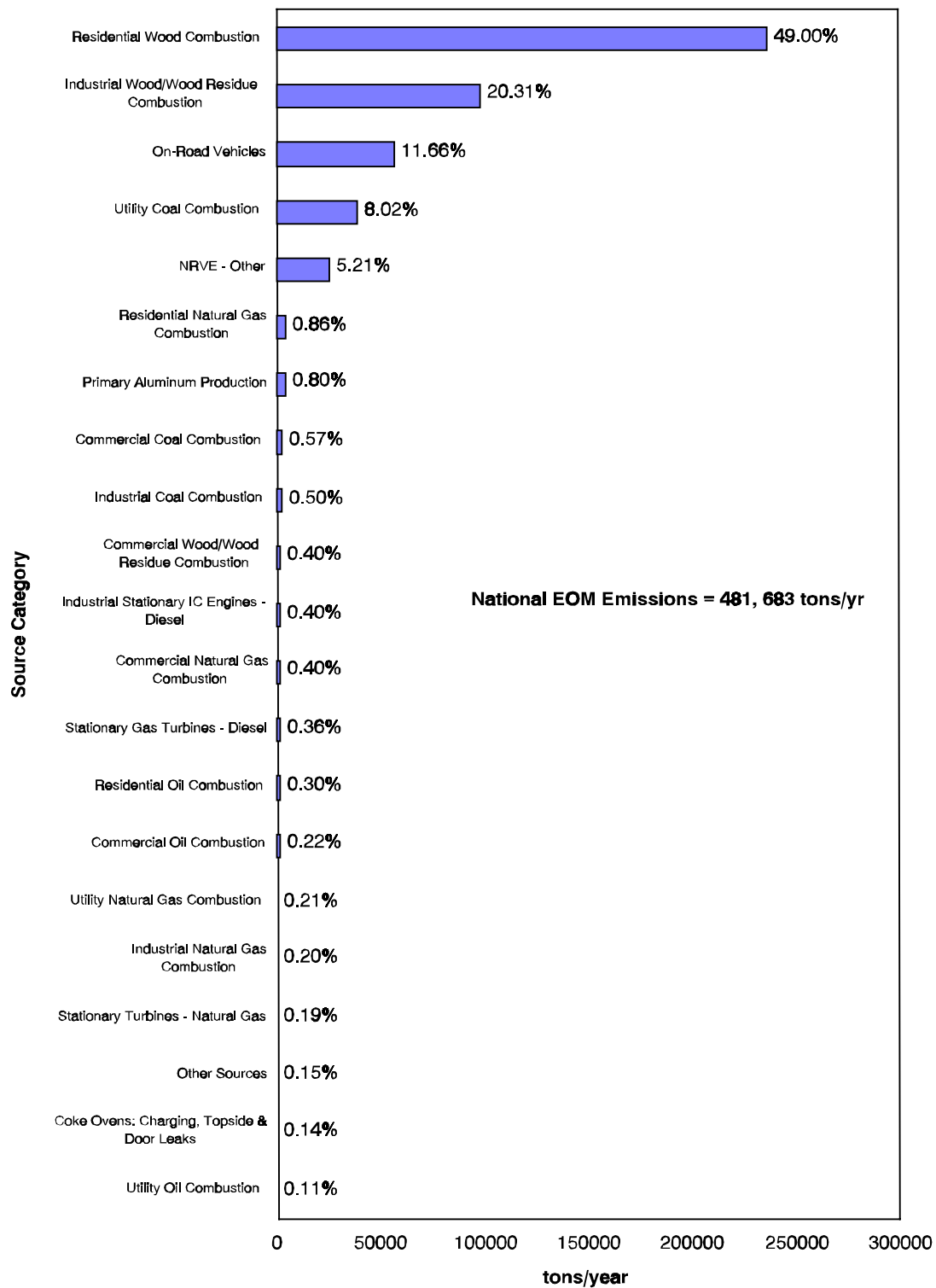


Figure 3-3. Percentage Contribution to 1990 National EOM Emissions by Source Category

recent data. This may explain, in part, the larger contribution from onroad vehicles for EOM (i.e., older vehicles typically have higher emissions than newer vehicles due to the engine technology, lack of sophisticated control devices, and disrepair). Lastly, the lack of broad source category coverage for EOM emissions hinders any relative comparisons between the different formats.

3.4.2 Major/Area Source Emissions

Using the allocation assumptions described in Chapter 2.0, 7-PAH, 16-PAH, and EOM national emissions were grouped, by source category, as to whether they originated from major or area sources. Table 3-3 shows the allocation of 7-PAH national emissions for each source category. The 16-PAH and EOM data on a major/area source basis are given in Tables 3-4 and 3-5, respectively.

For the 7-PAH data, area source emissions make up approximately 91 percent of the national total based largely on the contributions from wildfires and prescribed burning, residential wood combustion, and open burning of scrap tires. The data for 7-PAHs are difficult to completely interpret; however, since there are several source categories that have no estimates due to a lack of 7-PAH emission factor data. A similar, though not quite as significant, picture exists for the 16-PAH emissions total. The leading contributors are residential wood combustion (itself almost 50 percent of total emissions), wildfires and prescribed burning, open burning of scrap tires, kraft recovery furnaces, and gasoline distribution (driven by presence of naphthalene emissions component). The more significant major sources for 16-PAH emissions include kraft recovery furnaces, primary aluminum production, lime kilns, coke ovens, and catalytic cracking.

Area sources, in the aggregate, contribute a greater percentage (73 percent) of nationwide EOM emissions than major sources (27 percent). It is important to keep in

Table 3-3

**Allocation of 1990 Base Year 7-PAH National Emissions
By Major/Area Source Classifications**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| STATIONARY EXTERNAL COMBUSTION | | | |
| Residential Heating | | | |
| Residential Wood Combustion | 572 | 0 | 572 |
| Residential Natural Gas Combustion | 0.08 | 0 | 0.08 |
| Residential Distillate Oil Combustion | 1.7 | 0 | 1.7 |
| Residential Coal Combustion (bituminous and lignite) | 31.8 | 0 | 31.8 |
| Residential Coal Combustion (anthracite) | 0.052 | 0 | 0.052 |
| Utility, Industrial, and Commercial Boilers | | | |
| Utility Natural Gas Combustion | ND ^c | ND | ND |
| Utility Coal Combustion | 0.21 | 0.21 | 0 |
| Utility Residual Oil Combustion | 0.05 | 0.045 | 0.005 |
| Industrial Wood/Wood Residue Combustion | 2.67 | 2.14 | 0.53 |
| Industrial Natural Gas Combustion | ND | ND | ND |
| Industrial Coal Combustion | 3.09 | 2.16 | 0.93 |
| Industrial Residual Oil Combustion | 0.03 | 0.021 | 0.009 |
| Industrial Distillate Oil Combustion | 7.33E-04 | 5.13E-04 | 2.20E-04 |
| Industrial Waste Oil Combustion | 1.34 | 0.94 | 0.40 |
| Commercial Wood/Wood Residue Combustion | 1.01 | 0.20 | 0.81 |
| Commercial Natural Gas Combustion | ND | ND | ND |
| Commercial Coal Combustion (bituminous and lignite) | 36.0 | 7.2 | 28.8 |
| Commercial Coal Combustion (anthracite) | ND | ND | ND |
| Commercial Residual Oil Combustion | 0.03 | 0.006 | 0.024 |
| Commercial Distillate Oil Combustion | 1.57E-03 | 3.14E-04 | 1.26E-03 |
| STATIONARY INTERNAL COMBUSTION | | | |
| Industrial IC Engines | | | |
| Industrial IC Engines - Diesel | 0.089 | 0.062 | 0.027 |
| Industrial IC Engines - Natural Gas | 1.03 | 0.62 | 0.41 |
| Turbines | | | |
| Turbines - Diesel | ND | ND | ND |
| Turbines - Natural Gas | ND | ND | ND |

Table 3-3

**Allocation of 1990 Base Year 7-PAH National Emissions
By Major/Area Source Classifications (Continued)**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| WASTE INCINERATION | | | |
| Municipal Waste Combustion | ND | ND | ND |
| Sewage Sludge Incineration | 8.67E-03 | 0 | 8.67E-03 |
| Medical Waste Incineration | ND | ND | ND |
| Other Biological Waste Incineration | ND | ND | ND |
| Hazardous Waste Incineration | 0.02 | 0.02 | 0 |
| Drum and Barrel Reclamation | 1.27E-06 | 0 | 1.27E-06 |
| Scrap Tire Incineration | 2.17E-05 | 2.17E-05 | 0 |
| Landfill Flares | 1.05E-03 | 0 | 1.05E-03 |
| METALS INDUSTRY | | | |
| Primary Aluminum Production | 141 | 141 | 0 |
| Sintering in the Iron and Steel Foundries | ND | ND | ND |
| Ferroalloy Manufacturing | 0.26 | 0 | 0.26 |
| Iron and Steel Foundries | 0.11 | 0.11 | 0 |
| Secondary Lead Smelting | 0.019 | 0.015 | 0.004 |
| PETROLEUM REFINING | | | |
| Catalytic Cracking Units | 16.4 | 4.1 | 12.3 |
| ASPHALT PRODUCTION | | | |
| Asphalt Roofing Production | 1.68 | 0 | 1.68 |
| Asphalt Hot-mix Production | 0.094 | 0 | 0.094 |
| COKE PRODUCTION | | | |
| Coke Ovens: Charging, Topside, and Door Leaks | 21.2 | 21.2 | 0 |
| Coke Ovens: Pushing, Quenching, and Battery Stacks | 30.1 | 30.1 | 0 |
| PORTLAND CEMENT MANUFACTURING | | | |
| Portland Cement: Non-Hazardous Waste Kilns | 2.78 | 2.22 | 0.56 |
| Portland Cement: Hazardous Waste Kilns | 4.61 | 4.61 | 0 |
| PULP AND PAPER INDUSTRY | | | |
| Kraft Recovery Furnaces | 3.74 | 3.74 | 0 |
| Lime Kilns | 0.25 | 0.25 | 0 |
| Sulfite Recovery Furnaces | ND | ND | ND |

Table 3-3

**Allocation of 1990 Base Year 7-PAH National Emissions
By Major/Area Source Classifications (Continued)**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| OPEN BURNING | | | |
| Wildfires and Prescribed Burning | 964 | 0 | 964 |
| Open Burning of Scrap Tires | 307 | 0 | 307 |
| MOBILE SOURCES | | | |
| Onroad Vehicles | 18.8 | 0 | 18.8 |
| Aircraft | 0.07 | 0 | 0.07 |
| Locomotives | ND | ND | ND |
| Marine Vessels | ND | ND | ND |
| Non-road Vehicles and Equipment | ND | ND | ND |
| MISCELLANEOUS SOURCES | | | |
| Carbon Black Manufacturing | 0.45 | 0.14 | 0.31 |
| Wood Treatment/Wood Preserving (with creosote) | ND | ND | ND |
| Cigarette Smoke | 0.52 | 0 | 0.52 |
| Crematories | 1.42E-08 | 0 | 1.42E-08 |
| Gasoline Distribution | ND | ND | ND |
| Carbon Fiber Manufacturing | NA ^d | NA | NA |
| NAPHTHALENE PRODUCTION AND USE | | | |
| Naphthalene Production | ND | ND | ND |
| Phthalic Anhydride Production | ND | ND | ND |
| Carbamate Insecticides Production | ND | ND | ND |
| Naphthalene Sulfonates Production | ND | ND | ND |
| Miscellaneous Uses - Naphthalene | ND | ND | ND |
| TOTAL | 2,164.3 | 221.1 | 1,943.2 |

^aThese are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^bThese are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote a above.

^c"ND" indicates that there were no emission factors available for any of the compounds that comprise the

Table 3-3

Allocation of 1990 Base Year 7-PAH National Emissions By Major/Area Source Classifications (Continued)

7-PAH subset; therefore, a national emission estimate was not calculated.

^dNot available.

Table 3-4

**Allocation of 1990 Base Year 16-PAH National Emissions
By Major/Area Source Classifications**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| STATIONARY EXTERNAL COMBUSTION | | | |
| Residential Heating | | | |
| Residential Wood Combustion | 8,855 | 0 | 8,855 |
| Residential Natural Gas Combustion | 5.10 | 0 | 5.10 |
| Residential Distillate Oil Combustion | 21.0 | 0 | 21.0 |
| Residential Coal Combustion (bituminous and lignite) | 102.6 | 0 | 102.6 |
| Residential Coal Combustion (anthracite) | 0.226 | 0 | 0.226 |
| Utility, Industrial, and Commercial Boilers | | | |
| Utility Natural Gas Combustion | 0.69 | 0.62 | 0.07 |
| Utility Coal Combustion | 7.54 | 7.54 | 0 |
| Utility Residual Oil Combustion | 0.57 | 0.51 | 0.06 |
| Industrial Wood/Wood Residue Combustion | 152 | 121.6 | 30.4 |
| Industrial Natural Gas Combustion | 0.02 | 0.014 | 0.006 |
| Industrial Coal Combustion | 157 | 110 | 47 |
| Industrial Residual Oil Combustion | 44.7 | 31.3 | 13.4 |
| Industrial Distillate Oil Combustion | 6.15 | 4.31 | 1.84 |
| Industrial Waste Oil Combustion | 7.82 | 5.47 | 2.35 |
| Commercial Wood/Wood Residue Combustion | 35.8 | 7.16 | 28.6 |
| Commercial Natural Gas Combustion | 0.03 | 0.006 | 0.024 |
| Commercial Coal Combustion (bituminous and lignite) | 139 | 27.8 | 111.2 |
| Commercial Coal Combustion (anthracite) | 33.7 | 6.7 | 27.0 |
| Commercial Residual Oil Combustion | 40.1 | 8.0 | 32.1 |
| Commercial Distillate Oil Combustion | 13.2 | 2.6 | 10.6 |
| STATIONARY INTERNAL COMBUSTION | | | |
| Industrial IC Engines | | | |
| Industrial IC Engines - Diesel | 5.02 | 3.51 | 1.51 |
| Industrial IC Engines - Natural Gas | 47.6 | 28.6 | 19.0 |
| Turbines | | | |
| Turbines - Diesel | 0.0155 | 0.011 | 0.0045 |
| Turbines - Natural Gas | 13.8 | 8.3 | 5.5 |

Table 3-4

**Allocation of 1990 Base Year 16-PAH National Emissions
By Major/Area Source Classifications (Continued)**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| WASTE INCINERATION | | | |
| Municipal Waste Combustion | 0.099 | 0.094 | 0.005 |
| Sewage Sludge Incineration | 1.64 | 0 | 1.64 |
| Medical Waste Incineration | 0.80 | 0.12 | 0.68 |
| Other Biological Waste Incineration | ND ^c | ND | ND |
| Hazardous Waste Incineration | 0.17 | 0.17 | 0 |
| Drum and Barrel Reclamation | 8.19E-05 | 0 | 8.19E-05 |
| Scrap Tire Incineration | 5.18E-03 | 5.18E-03 | 0 |
| Landfill Flares | 0.445 | 0 | 0.445 |
| METALS INDUSTRY | | | |
| Primary Aluminum Production | 662 | 662 | 0 |
| Sintering in the Iron and Steel Foundries | ND | ND | ND |
| Ferroalloy Manufacturing | 0.56 | 0 | 0.56 |
| Iron and Steel Foundries | 29.7 | 29.7 | 0 |
| Secondary Lead Smelting | 3.03 | 2.42 | 0.61 |
| PETROLEUM REFINING | | | |
| Catalytic Cracking Units | 313 | 78.2 | 234.8 |
| ASPHALT PRODUCTION | | | |
| Asphalt Roofing Production | 43.6 | 0 | 43.6 |
| Asphalt Hot-mix Production | 43.7 | 0 | 43.7 |
| COKE PRODUCTION | | | |
| Coke Ovens: Charging, Topside, and Door Leaks | 158 | 158 | 0 |
| Coke Ovens: Pushing, Quenching, and Battery Stacks | 516.6 | 516.6 | 0 |
| PORTLAND CEMENT MANUFACTURING | | | |
| Portland Cement: Non-Hazardous Waste Kilns | 51.0 | 40.8 | 10.2 |
| Portland Cement: Hazardous Waste Kilns | 28.0 | 28.0 | 0 |
| PULP AND PAPER INDUSTRY | | | |
| Kraft Recovery Furnaces | 649 | 649 | 0 |
| Lime Kilns | 183 | 183 | 0 |
| Sulfite Recovery Furnaces | 6.17 | 6.17 | 0 |

Table 3-4

**Allocation of 1990 Base Year 16-PAH National Emissions
By Major/Area Source Classifications (Continued)**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| OPEN BURNING | | | |
| Wildfires and Prescribed Burning | 2,540 | 0 | 2,540 |
| Open Burning of Scrap Tires | 1,720 | 0 | 1,720 |
| MOBILE SOURCES | | | |
| Onroad Vehicles | 46.6 | 0 | 46.6 |
| Aircraft | 1.87 | 0 | 1.87 |
| Locomotives | ND | ND | ND |
| Marine Vessels | ND | ND | ND |
| Non-road Vehicles and Equipment | ND | ND | ND |
| MISCELLANEOUS SOURCES | | | |
| Carbon Black Manufacturing | 4.33 | 1.30 | 3.03 |
| Wood Treatment/Wood Preserving (with creosote) | 457 | 0 | 457 |
| Cigarette Smoke | 3.45 | 0 | 3.45 |
| Crematories | 8.33E-06 | 0 | 8.33E-06 |
| Gasoline Distribution | 727 | 72.7 | 654.3 |
| Carbon Fiber Manufacturing | NA ^d | NA | NA |
| NAPHTHALENE PRODUCTION AND USE | | | |
| Naphthalene Production | 64.6 | 45.2 | 19.4 |
| Phthalic Anhydride Production | 26.20 | 18.34 | 7.86 |
| Carbamate Insecticides Production | 4.08 | 1.22 | 2.86 |
| Naphthalene Sulfonates Production | 6.53 | 4.57 | 1.96 |
| Miscellaneous Uses - Naphthalene | 1.22 | 0 | 1.22 |
| TOTAL | 17,982 | 2,872 | 15,110 |

^aThese are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^bThese are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote a above.

Table 3-4

Allocation of 1990 Base Year 16-PAH National Emissions By Major/Area Source Classifications (Continued)

^c"ND" indicates that there were no emission factors available for any of the compounds that comprise the 16-PAH subset; therefore, a national emission estimate was not calculated.

^dNot available.

Table 3-5

**Allocation of 1990 Base Year EOM National Emissions
By Major/Area Source Classifications**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| STATIONARY EXTERNAL COMBUSTION | | | |
| Residential Heating | | | |
| Residential Wood Combustion | 235,881 | 0 | 235,881 |
| Residential Natural Gas Combustion | 4,142 | 0 | 4,142 |
| Residential Distillate Oil Combustion | 1,465 | 0 | 1,465 |
| Residential Coal Combustion (bituminous and lignite) | ND ^c | ND | ND |
| Residential Coal Combustion (anthracite) | ND | ND | ND |
| Utility, Industrial, and Commercial Boilers | | | |
| Utility Natural Gas Combustion | 1,004 | 904 | 100 |
| Utility Coal Combustion | 38,627 | 38,627 | 0 |
| Utility Residual Oil Combustion | 531 | 478 | 53 |
| Industrial Wood/Wood Residue Combustion | 97,848 | 78,278 | 19,570 |
| Industrial Natural Gas Combustion | 928 | 650 | 278 |
| Industrial Coal Combustion | 2,412 | 1,688 | 724 |
| Industrial Residual Oil Combustion | 97 | 68 | 29 |
| Industrial Distillate Oil Combustion | 397 | 278 | 119 |
| Industrial Waste Oil Combustion | ND | ND | ND |
| Commercial Wood/Wood Residue Combustion | 1,946 | 389 | 1,557 |
| Commercial Natural Gas Combustion | 1,921 | 384 | 1,537 |
| Commercial Coal Combustion (bituminous and lignite) | 2,744 | 549 | 2,195 |
| Commercial Coal Combustion (anthracite) | ND | ND | ND |
| Commercial Residual Oil Combustion | 350 | 70 | 280 |
| Commercial Distillate Oil Combustion | 965 | 193 | 772 |
| STATIONARY INTERNAL COMBUSTION | | | |
| Industrial IC Engines | | | |
| Industrial IC Engines - Diesel | 1,929 | 1,350 | 579 |
| Industrial IC Engines - Natural Gas | ND | ND | ND |
| Turbines | | | |
| Turbines - Diesel | 1,731 | 1,212 | 519 |
| Turbines - Natural Gas | 739 | 443 | 296 |

Table 3-5

**Allocation of 1990 Base Year EOM National Emissions
By Major/Area Source Classifications (Continued)**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| WASTE INCINERATION | | | |
| Municipal Waste Combustion | 182 | 173 | 9 |
| Sewage Sludge Incineration | ND | ND | ND |
| Medical Waste Incineration | 15 | 2 | 13 |
| Other Biological Waste Incineration | 1 | 0 | 1 |
| Hazardous Waste Incineration | ND | ND | ND |
| Drum and Barrel Reclamation | ND | ND | ND |
| Scrap Tire Incineration | ND | ND | ND |
| Landfill Flares | ND | ND | ND |
| METALS INDUSTRY | | | |
| Primary Aluminum Production | 3,876 | 3,876 | 0 |
| Sintering in the Iron and Steel Foundries | ND | ND | ND |
| Ferroalloy Manufacturing | ND | ND | ND |
| Iron and Steel Foundries | ND | ND | ND |
| Secondary Lead Smelting | ND | ND | ND |
| PETROLEUM REFINING | | | |
| Catalytic Cracking Units | ND | ND | ND |
| ASPHALT PRODUCTION | | | |
| Asphalt Roofing Production | ND | ND | ND |
| Asphalt Hot-mix Production | ND | ND | ND |
| COKE PRODUCTION | | | |
| Coke Ovens: Charging, Topside, and Door Leaks | 679 | 679 | 0 |
| Coke Ovens: Pushing, Quenching, and Battery Stacks | ND | ND | ND |
| PORTLAND CEMENT MANUFACTURING | ND | ND | ND |
| PULP AND PAPER INDUSTRY | | | |
| Kraft Recovery Furnaces | ND | ND | ND |
| Lime Kilns | ND | ND | ND |
| Sulfite Recovery Furnaces | ND | ND | ND |
| OPEN BURNING | | | |
| Wildfires and Prescribed Burning | ND | ND | ND |
| Open Burning of Scrap Tires | ND | ND | ND |

Table 3-5

**Allocation of 1990 Base Year EOM National Emissions
By Major/Area Source Classifications (Continued)**

| Source Category | Total National Emissions (tons/yr) | Major Source Emissions (tons/yr) ^a | Area Source Emissions (tons/yr) ^b |
|--|------------------------------------|---|--|
| MOBILE SOURCES | | | |
| Onroad Vehicles | 56,157 | 0 | 56,157 |
| Aircraft | ND | ND | ND |
| Locomotives | ND | ND | ND |
| Marine Vessels | ND | ND | ND |
| Non-road Vehicles and Equipment | 25,116 | 0 | 25,116 |
| MISCELLANEOUS SOURCES | | | |
| Carbon Black Manufacturing | ND | ND | ND |
| Wood Treatment/Wood Preserving (with creosote) | ND | ND | ND |
| Cigarette Smoke | ND | ND | ND |
| Crematories | ND | ND | ND |
| Gasoline Distribution | ND | ND | ND |
| Carbon Fiber Manufacturing | ND | ND | ND |
| NAPHTHALENE PRODUCTION AND USE | | | |
| Naphthalene Production | ND | ND | ND |
| Phthalic Anhydride Production | ND | ND | ND |
| Carbamate Insecticides Production | ND | ND | ND |
| Naphthalene Sulfonates Production | ND | ND | ND |
| Miscellaneous Uses - Naphthalene | ND | ND | ND |
| TOTAL | 481,683 | 130,291 | 351,392 |

^aThese are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^bThese are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote a above.

^c"ND" indicates that there were no emission factors available for EOM; therefore, a national emission estimate was not calculated.

mind that this inventory does not include all EOM sources, particularly some potentially large contributors such as kraft recovery furnaces and lime kilns. There are only three categories in the inventory that are assumed to be entirely major sources: coke ovens, primary aluminum production and utility coal combustion. Except for utility coal combustion, these other two categories contribute relatively small amounts to the national EOM emissions but are individually major sources of EOM. Residential woodcombustion, on the other hand, is strictly an area source, with a large contribution to the national EOM emission total that weights the national emission contribution heavily towards area sources.

3.5 References

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4.0 EMISSION ESTIMATES FOR 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD)/2,3,7,8-TETRACHLORODIBENZOFURAN (TCDF)

4.1 Emission Factors for 2,3,7,8-TCDD, 2,3,7,8-TCDF, and 2,3,7,8-TCDD TEQ

Emissions estimates for dioxin and furan species are reported for two specific congeners: 2,3,7,8-TCDD and 2,3,7,8-TCDF. The two 2,3,7,8 congeners of dioxins and furans represent the most toxic compounds of their respective families and have been specifically targeted by Section 112(c)(6) of the CAAA for consideration. Other dioxin and furan congeners have varying levels of toxicity. To aid in ranking the health risk contribution of all dioxin and furan emissions, another reporting scheme is employed, namely that of reporting total dioxin and furan emissions in TEQ to 2,3,7,8-TCDD (U.S. EPA, 1986; U.S. EPA, 1989; Heuvel et al., 1993). The toxicity equivalency factor (TEF) ranking scheme is a method for evaluating the risks inherent with exposure to mixtures of chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs). The 2,3,7,8-TCDD and 2,3,7,8-TCDF are only 2 of 210 structurally related CDDs and CDFs, where each CDD/CDF structural variation is called a congener.

The compound 2,3,7,8-TCDD has been identified as the most toxic of all the CDDs and CDFs. For this reason, it has been selected as the reference compound against which the toxicity of all the other CDDs and CDFs can be related. 2,3,7,8-TCDD has been assigned TEF of 1.0, and all the other CDD/CDF congeners have been assigned a TEF of some fraction of 1.0, based on their relative toxicity compared to 2,3,7,8-TCDD.

The risk inherent in a CDD/CDF mixture can be determined as follows using the TEF approach (U.S. EPA, 1996c):

- Analytically determine the concentration of all of the CDDs and CDF congeners in a sample;
- Multiply the concentration of each analyzed congener by its assigned TEF to express its concentration in terms of TEQs;

- Sum the concentrations in terms of TEQs for every congener in Step 2; and
- The summed TEQ can then be used to evaluate the health risk of the mixture by comparing it to the risk of an equal concentration of 100 percent 2,3,7,8-TCDD.

To reflect the TEQ emissions of dioxins and furans in this manner, emission estimates of 2,3,7,8-TCDD TEQ are presented in this report. In most cases, emission estimates are reported as an annual value representative of the 1990 base year. As discussed previously, the year 1990 was selected because it is the year the CAAA were enacted.

The emission factors for 2,3,7,8-TCDD, 2,3,7,8-TCDF, and 2,3,7,8-TCDD TEQ used to develop 1990 national emission estimates for this study are presented in Table 4-1.

4.2 Source Category Inclusion

The dioxin and furan source categories were identified based on an in-depth review of available literature sources and previously developed national inventories. This review was conducted parallel with a national exposure study of dioxins and furans performed by the EPA's Office of Health and Environmental Assessment (OHEA). National emissions estimates were developed for all source categories with documented emission factors or with credible national estimates. Note that only 2,3,7,8-TCDD TEQ national emission estimates were available from the OHEA study for two source categories: other biological waste incineration and forest fires. Table 4-1 identifies the categories for which 1990 base year national emissions were determined.

The following categories were identified as potential sources of dioxin and furan emissions for which sufficient data were not available to develop credible national emissions estimates:

- Ethylene Dichloride and Vinyl Chloride Monomer Manufacture;

Table 4-1
Emission Factors for Calculating 1990 Base Year National Dioxin
and Furan Emissions Estimates^a

| Source Category | 1990 National Annual Activity Level | 2,3,7,8-TCDD Emission Factor | 2,3,7,8-TCDF Emission Factor | 2,3,7,8-TCDD TEQ Emission Factor |
|---|--|--|--|--|
| Municipal Waste Combustion | b | b | b | b |
| Medical Waste Incineration | b | b | b | b |
| Other Biological Waste Incineration | 1.2 x 10 ⁵ tons waste burned | NA ^c | NA | 2.72 x 10 ⁻⁶ lb/ton waste incinerated |
| Sewage Sludge Incineration ^d | 9.5 x 10 ⁵ tons incinerated | 1.0 x 10 ⁻⁹ lb/ton sludge incinerated | 3.6 x 10 ⁻⁷ lb/ton sludge incinerated | 5.57 x 10 ⁻⁸ lb/ton sludge incinerated |
| Hazardous Waste Incineration ^e | 1.43 x 10 ⁶ tons incinerated | 1.68 x 10 ⁻¹⁰ lb/ton waste incinerated | 1.91 x 10 ⁻⁸ lb/ton waste incinerated | b |
| Portland Cement: Non-Hazardous Waste | 67.6 x 10 ⁶ tons clinker produced | NA | NA | 1.78 x 10 ⁻⁹ lb/ton clinker produced |
| Portland Cement: Hazardous Waste | b | NA | NA | b |
| Light Weight Aggregate Kilns | b | NA | NA | b |
| Scrap Tire Incineration | 5.5 x 10 ⁵ tons incinerated | 2.16 x 10 ⁻¹¹ lb/ton tires incinerated | 5.42 x 10 ⁻¹¹ lb/ton tires incinerated | 1.08 x 10 ⁻⁹ lb/ton tires incinerated |
| Industrial Wood Combustion | 9.06 x 10 ⁷ short tons dried wood burned | 7.34 x 10 ⁻¹¹ lb/short ton dry wood burned | 1.05 x 10 ⁻¹⁰ lb/short ton dry wood burned | 2.48 x 10 ⁻⁹ lb/short ton dry wood burned |
| Residential Coal Combustion | 1,929,000 tons bituminous coal 732,000 tons anthracite burned | 4.79 x 10 ⁻⁹ lb/ton bituminous coal burned 3.20 x 10 ⁻⁹ lb/ton anthracite coal burned | 1.26 x 10 ⁻⁷ lb/ton bituminous coal burned 8.39 x 10 ⁻⁸ lb/ton anthracite coal burned | 1.97 x 10 ⁻⁷ lb/ton bituminous coal burned 1.20 x 10 ⁻⁷ lb/ton anthracite coal burned |

Table 4-1

**Emission Factors for Calculating 1990 Base Year National Dioxin
and Furan Emissions Estimates^a (Continued)**

| Source Category | 1990 National Annual Activity Level | 2,3,7,8-TCDD Emission Factor | 2,3,7,8-TCDF Emission Factor | 2,3,7,8-TCDD TEQ Emission Factor |
|---|--|---|---|---|
| Residential Distillate Fuel Combustion | 1.44 x 10 ⁸ barrels burned | 1.96 x 10 ⁻⁸ lb/10 ³ barrels burned | 1.86 x 10 ⁻⁸ lb/10 ³ barrels burned | 5.26 x 10 ⁻⁸ lb/10 ³ barrels burned |
| Residential Wood Combustion | 3.38 x 10 ⁷ tons dried wood burned | 2.55 x 10 ⁻¹¹ lb/ton dry wood burned | 8.9 x 10 ⁻¹⁰ lb/ton dry wood burned | 2.0 x 10 ⁻⁹ lb/ton dry wood burned |
| Iron and Steel Foundries | 1.02 x 10 ⁷ tons iron/steel product | 2.47 x 10 ⁻¹⁰ lb/ton product | 7.92 x 10 ⁻⁹ lb/ton product | 3.68 x 10 ⁻⁹ lb/ton product |
| Secondary Copper Smelters | 3.89 x 10 ⁵ tons smelter feed | NA | NA | NA |
| Secondary Lead Smelters | 948,000 tons lead produced | f | f | f |
| Secondary Aluminum Production | b | b | b | b |
| Drum and Barrel Reclamation/ Incineration | 4.60 x 10 ⁶ 55-gallon drums burned | 4.61 x 10 ⁻⁹ lb/10 ³ drums burned | 8.05 x 10 ⁻⁸ lb/10 ³ drums burned | 1.09 x 10 ⁻⁷ lb/10 ³ drums burned |
| Onroad Mobile Sources | 2.15 x 10 ¹² vehicle miles of travel | 3.6 x 10 ⁻¹⁵ lb/vehicle mile | 5.65 x 10 ⁻¹⁴ lb/vehicle mile | 8.85 x 10 ⁻¹⁴ lb/vehicle mile |
| Pulp and Paper/Kraft Recovery Furnaces | 3.11 x 10 ⁷ tons black liquor solids burned | 2,3,7,8-TCDD Emissions Not Detected in Emission Factor Database | NA | 2.2 x 10 ⁻¹¹ lb/ton black liquor solids |
| Pentachlorophenol (PCP) Wood Treatment | 2.16 x 10 ⁷ lbs PCP used for wood treatment | 2,3,7,8-TCDD Emissions Not Detected in Emission Factor Database | NA | 7.06 x 10 ⁻⁶ lb/ton PCP |
| Carbon Reactivation Furnaces | 7.19 x 10 ⁴ tons reactivated carbon | 2.10 x 10 ⁻¹⁰ lb/ton carbon reactivated | 1.36 x 10 ⁻⁹ lb/ton carbon reactivated | 3.46 x 10 ⁻⁹ lb/ton carbon reactivated |
| Forest Fires | 9.5 x 10 ⁷ tons biomass burned | NA | NA | 2 x 10 ⁻⁹ lb/ton biomass burned |

Table 4-1

**Emission Factors for Calculating 1990 Base Year National Dioxin
and Furan Emissions Estimates^a (Continued)**

| Source Category | 1990 National Annual Activity Level | 2,3,7,8-TCDD Emission Factor | 2,3,7,8-TCDF Emission Factor | 2,3,7,8-TCDD TEQ Emission Factor |
|---------------------------------|--|--------------------------------------|--------------------------------------|--------------------------------------|
| Utility Coal Combustion | 773,824,190 tons bituminous coal | 3.62×10^{-11} lb/ton coal | 8.79×10^{-11} lb/ton coal | 3.88×10^{-10} lb/ton coal |
| Utility Residual Oil Combustion | 200,129,650 barrels oil | 4.0×10^{-11} lb/barrels oil | 2.9×10^{-11} lb/barrels oil | 1.1×10^{-10} lb/barrels oil |

^aThe derivation of the emissions data and assumptions presented in this table are explained in detail in Appendix A.

^bThese estimates were obtained from the MACT or other regulatory development programs. The method used to estimates total emissions is based on emissions from individual facilities and not on activity data and emission factors.

^cNot available.

^dDioxin/furan emission estimates from sewage sludge incinerators are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^eEmissions estimate for this category represents emissions from dedicated hazardous waste incinerators. It does not include BIFs. Separate estimates are provided for Portland cement kilns burning hazardous waste and light weight aggregate kilns burning hazardous waste. No estimate is available for other BIFs.

^fNational emissions were calculated using a matrix of emission factors corresponding to different furnace types and control devices. See Appendix A for a specification of factors.

- Boilers and Industrial Furnaces burning hazardous waste (exclusive of Portland cement kilns and lightweight aggregate kilns);
- Lime Manufacture;
- Petroleum Refining (Catalyst Regeneration);
- Chlorophenol Manufacture; and
- Pulp and Paper Bleached Sludge Burning.

Data for developing emission factors for petroleum refining catalyst regeneration were originally anticipated from the EPA's Petroleum Refinery's NESHAP effort. However, the applicable data obtained through this program were found to contain problems that made them unusable for the purposes of this project. Data for developing emission factors for combustion of landfill gas in flares were also obtained; however, national activity data for landfills were not identified. Thus, national emission estimates for landfills were not determined. In addition, it should be noted that no attempt was made to limit coverage to only those stationary sources that may be subject to requirements of Section 112.

4.3 Detailed Emissions Summary

This section presents the total 1990 base year national emissions for 2,3,7,8-TCDD TEQ, and national emissions for all but three source categories for 2,3,7,8-TCDD and all but five source categories for 2,3,7,8-TCDF. The 1990 national emissions of each pollutant form have also been allocated as to whether they come from major or area source categories (see Chapter 2.0 for the definition of major and area sources). Appendix A provides documentation on how all emission estimates were calculated; emission factors and activity data are provided. For the categories of municipal waste combustion, medical waste incineration, hazardous waste incineration and Portland cement kilns (non-hazardous and hazardous waste burning), recent regulatory programs provided the bulk of the national emissions data (U.S. EPA 1996a; U.S. EPA, 1996b; Heath, 1996; Rizeq, 1997a; Rizeq, 1997b).

Current emissions for several of these source categories (e.g., MWCs, cement kilns, and MWIs) are significantly below the 1990 levels shown here due to the development and application by EPA of various MACT standards. For these source categories, the 1990 estimates are not representative of the reduced contributions these categories are making to current national emission levels.

4.3.1 National Emissions

Tables 4-2 through 4-4 present the 1990 national emissions of 2,3,7,8-TCDD, 2,3,7,8-TCDF, and 2,3,7,8-TCDD TEQ for each source category. The tables also present the partitioning of total emissions between major and area sources. All source categories presented in this report are currently listed in the EPA's Section 112 list of major sources (see Section 2.5, Reference No. 1) except for the following:

- Secondary Copper Smelters;
- Residential Coal Combustion;
- Residential Distillate Fuel Combustion;
- Residential Wood Combustion;
- Drum and Barrel Reclamation/Incineration;
- Onroad Mobile Sources;
- Forest Fires; and
- Other Biological Incineration.

Since complete emissions estimates are only available for the 2,3,7,8-TCDD TEQ basis, summary statistics are only discussed for this pollutant form. Both the 2,3,7,8-TCDD and 2,3,7,8-TCDF data have source categories for which estimates are missing; therefore, discussions of dominant emitting categories could be misleading. Total national 2,3,7,8-TCDD TEQ emissions are estimated to be 12.12 lbs/yr, with 9.0 lbs/yr

Table 4-2

**National 1990 Base Year 2,3,7,8-TCDD Emissions and Emissions
by Major/Area Source Classification**

| Source Category | Number of U.S. Facilities | Total National Emissions (lb/yr) ^a | Major Source Emissions (lb/yr) ^b | Area Source Emissions (lb/yr) ^c |
|--|---|---|---|--|
| Municipal Waste Combustion ^d | 158 | e | e | e |
| Medical Waste Incineration | 3,400 | e | e | e |
| Residential Wood Combustion | 22.5 x 10 ⁶ Households ^f | 8.62x10 ⁻⁴ | 0.00 | 8.62 x 10 ⁻⁴ |
| Secondary Copper Smelters | 4 | 1.36x10 ⁻² | 1.36x10 ⁻² | 0.00 |
| Industrial Wood Combustion | 45,150 | 6.65 x 10 ⁻³ | 0.0053 | 0.0013 |
| Utility Coal Combustion | 1,201 | 0.028 | 0.028 | 0 |
| Residential Coal Combustion | Unknown | 0.0116 | 0.00 | 0.0116 |
| Utility Residual Oil Combustion | 545 | 8.0 x 10 ⁻³ | 7.2 x 10 ⁻³ | 8.0 x 10 ⁻⁴ |
| Hazardous Waste Incineration | 150 | 2.2 x 10 ⁻⁴ | 2.2 x 10 ⁻⁴ | 0.00 |
| Residential Distillate Fuel Combustion | 10.1 x 10 ⁶ Households ^f | 2.82 x 10 ⁻³ | 0.00 | 2.82 x 10 ⁻³ |
| Iron and Steel Foundries | 1,100 | 2.52 x 10 ⁻³ | 2.52 x 10 ⁻³ | 0.00 |
| Secondary Lead Smelters | 22 | 1.95 x 10 ⁻³ | 1.56 x 10 ⁻³ | 3.90 x 10 ⁻⁴ |
| Sewage Sludge Incineration ^g | 174 | 9.5 x 10 ⁻⁴ | 0.00 | 9.50 x 10 ⁻⁴ |
| Secondary Aluminum Production | 23 | e | e | e |
| Onroad Mobile Sources | 165 x 10 ⁶ Vehicles | 7.74 x 10 ⁻³ | 0.00 | 7.74 x 10 ⁻³ |
| Drum and Barrel Reclamation/ Incineration | 12 | 2.12 x 10 ⁻⁵ | 0.00 | 2.12 x 10 ⁻⁵ |
| Carbon Reactivation Furnaces | Unknown | 1.51 x 10 ⁻⁵ | 3.8 x 10 ⁻⁶ | 1.13 x 10 ⁻⁵ |
| Scrap Tire Incineration | 18 | 1.19 x 10 ⁻⁵ | 1.19 x 10 ⁻⁵ | 0.00 |
| Pentachlorophenol Wood Treatment ^h | 39 | 0.00 | 0.00 | 0.00 |
| Pulp and Paper/Kraft Recovery Furnaces ⁱ | 149 | 0.00 | 0.00 | 0.00 |
| Portland Cement: Non-Hazardous Waste Kilns | 90 | NA ^j | NA | NA |

Table 4-2

**National 1990 Base Year 2,3,7,8-TCDD Emissions and Emissions
by Major/Area Source Classification (Continued)**

| Source Category | Number of U.S. Facilities | Total National Emissions (lb/yr) ^a | Major Source Emissions (lb/yr) ^b | Area Source Emissions (lb/yr) ^c |
|--|---------------------------------|---|---|--|
| Portland Cement: Hazardous Waste Kilns | 20 | NA | NA | NA |
| Other Biological Incineration | 1,700 | NA | NA | NA |
| Forest Fires | Not applicable | NA | NA | NA |
| Crematories | 395 | 1.83 x 10 ⁻⁸ | 0.00 | 1.83 x 10 ⁻⁸ |

^aNumbers may not sum across rows due to rounding.

^bThese are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^cThese are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote b above.

^dDioxin/furan emission estimates from municipal waste combustors are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^eDioxin/furan estimates for these categories were obtained from EPA MACT development programs. Estimates are available at this time only for 2,3,7,8-TCDD TEQ.

^fHouseholds for which the specified fuel is the primary heating source.

^gDioxin/furan emission estimates from sewage sludge incinerators are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^h2,3,7,8-TCDD emissions were not detected in tests used for emission factor calculation. Number of facilities consists of 24 that use PCP exclusively and 15 that use both PCP and creosote.

ⁱ2,3,7,8-TCDD emissions were not detected in tests used for emission factor calculation.

^jNot available.

Table 4-3

**National 1990 Base Year 2,3,7,8-TCDF Emissions and Emissions
by Major/Area Source Classification**

| Source Category | Number of U.S. Facilities | Total National Emissions (lb/yr) ^a | Major Source Emissions (lb/yr) ^b | Area Source Emissions (lb/yr) ^c |
|--|---|--|---|--|
| Municipal Waste Combustion ^d | 158 | e | e | e |
| Residential Wood Combustion | 22.5 x 10 ⁶ households ^f | 0.030 | 0.00 | 0.030 |
| Secondary Copper Smelters | 4 | NA ^g | NA | NA |
| Medical Waste Incineration | 3,400 | e | e | e |
| Hazardous Waste Incineration | 150 | 0.025 | 0.025 | 0.00 |
| Sewage Sludge Incineration ^h | 174 | 0.342 | 0.00 | 0.342 |
| Residential Coal Combustion | Unknown | 0.304 | 0.00 | 0.304 |
| Industrial Wood Combustion | 45,150 | 9.51 x 10 ⁻³ | 7.6 x 10 ⁻³ | 1.9 x 10 ⁻³ |
| Iron and Steel Foundries | 1,100 | 0.0808 | 0.0808 | 0.00 |
| Utility Coal Combustion | 1,201 | 0.068 | 0.068 | 0.00 |
| Secondary Lead Smelters | 22 | 0.0120 | 9.6 x 10 ⁻³ | 2.4 x 10 ⁻³ |
| Utility Residual Oil Combustion | 545 | 5.8 x 10 ⁻³ | 5.2 x 10 ⁻³ | 6.00 x 10 ⁻⁴ |
| Secondary Aluminum Production | 23 | e | e | e |
| Residential Distillate Fuel Combustion | 10.1 x 10 ⁶ households ^f | 2.67 x 10 ⁻³ | 0.00 | 2.67 x 10 ⁻³ |
| Onroad Mobile Sources | 165 x 10 ⁶ vehicles | 0.121 | 0.00 | 0.121 |
| Drum and Barrel Reclamation/ Incineration | 12 | 3.70 x 10 ⁻⁴ | 0.00 | 3.70 x 10 ⁻⁴ |
| Carbon Reactivation Furnaces | Unknown | 9.77 x 10 ⁻⁵ | 2.44 x 10 ⁻⁵ | 7.33 x 10 ⁻⁵ |
| Scrap Tire Incineration | 18 | 2.98 x 10 ⁻⁵ | 2.98 x 10 ⁻⁵ | 0.00 |
| Pulp and Paper/Kraft Recovery Furnaces | 149 | NA | NA | NA |
| Pentachlorophenol Wood Treatment ⁱ | 39 | NA | NA | NA |
| Portland Cement | 110 | NA | NA | NA |

Table 4-3

**National 1990 Base Year 2,3,7,8-TCDF Emissions and Emissions
by Major/Area Source Classification (Continued)**

| Source Category | Number of U.S. Facilities | Total National Emissions (lb/yr) ^a | Major Source Emissions (lb/yr) ^b | Area Source Emissions (lb/yr) ^c |
|-------------------------------|---------------------------|---|---|--|
| Other Biological Incineration | 1,700 | NA | NA | NA |
| Forest Fires | Not applicable | NA | NA | NA |
| Crematories | 395 | 1.33×10^{-7} | 0.00 | 1.33×10^{-7} |

^aNumbers may not sum across rows due to rounding.

^bThese are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^cThese are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote b above.

^dDioxin/furan emission estimates from municipal waste combustors are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^eDioxin/furan estimates for these categories were obtained from EPA MACT development programs. Estimates are available at this time only for 2,3,7,8-TCDD TEQ.

^fHouseholds for which the specified fuel is the primary heating source.

^gNot available.

^hDioxin/furan emission estimates from sewage sludge incinerators are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

ⁱNumber of facilities consists of 24 that use PCP exclusively and 15 that use both PCP and creosote.

Table 4-4

**National 1990 Base Year 2,3,7,8-TCDD TEQ Emissions and Emissions
by Major/Area Source Classification**

| Source Category | Number of U.S. Facilities | Total National Emissions (lb/yr) ^a | Major Source Emissions (lb/yr) ^b | Area Source Emissions (lb/yr) ^c |
|--|---|--|---|--|
| Municipal Waste Combustion ^d | 158 | 7.30 | 6.94 | 0.36 |
| Medical Waste Incineration ^e | 3,400 | 1.32 | 0.20 | 1.12 |
| Portland Cement: Non-Hazardous Waste Fired | 90 | 0.12 | 0.10 | 0.02 |
| Portland Cement: Hazardous Waste Fired ^f | 20 | 0.95 | 0.95 | 0.00 |
| Industrial Wood Combustion | 45,150 | 0.225 | 0.180 | 0.045 |
| Secondary Copper Smelters | 4 | 1.36×10^{-2} | 3.4×10^{-3} | 1.02×10^{-2} |
| Residential Coal Combustion | Unknown | 0.468 | 0.00 | 0.468 |
| Other Biological Incineration | 1,700 | 0.32 | 0.00 | 0.32 |
| Utility Coal Combustion | 1,201 | 0.3 | 0.3 | 0.00 |
| Forest Fires | NA ^g | 0.19 | 0.00 | 0.19 |
| Onroad Mobile Sources | 165×10^6 vehicles | 0.19 | 0.00 | 0.19 |
| Residential Wood Combustion | 22.5×10^6 households ^h | 0.068 | 0.00 | 0.068 |
| Pentachlorophenol Wood Treatment ⁱ | 39 | 0.076 | 0.00 | 0.076 |
| Sewage Sludge Incineration ^j | 174 | 0.053 | 0.00 | 0.053 |
| Iron and Steel Foundries | 1,100 | 0.038 | 0.038 | 0.00 |
| Secondary Aluminum Production | 23 | 0.38 | 0.19 | 0.19 |
| Utility Residual Oil Combustion | 545 | 0.022 | 0.02 | 0.002 |
| Hazardous Waste Incineration ^k | 150 | 0.066 | 0.066 | 0.00 |
| Secondary Lead Smelters | 22 | 8.49×10^{-3} | 6.79×10^{-3} | 1.7×10^{-3} |
| Residential Distillate Fuel Combustion | 10.1×10^6 households ^h | 7.56×10^{-3} | 0.00 | 7.56×10^{-3} |

Table 4-4

**National 1990 Base Year 2,3,7,8-TCDD TEQ Emissions and Emissions
by Major/Area Source Classification (Continued)**

| Source Category | Number of U.S. Facilities | Total National Emissions (lb/yr) ^a | Major Source Emissions (lb/yr) ^b | Area Source Emissions (lb/yr) ^c |
|---|---------------------------------|--|---|--|
| Pulp and Paper/Kraft Recovery Furnaces | 149 | 6.84×10^{-4} | 6.84×10^{-4} | 0.00 |
| Drum and Barrel Reclamation/ Incineration | 12 | 5.01×10^{-4} | 0.00 | 5.01×10^{-4} |
| Scrap Tire Incineration | 18 | 6.0×10^{-4} | 6.0×10^{-4} | 0.00 |
| Lightweight Aggregate Kilns (Hazardous Waste) ^d | 5 | 0.0072 | 0.0072 | 0.00 |
| Carbon Reactivation Furnaces | Unknown | 2.49×10^{-4} | 6.2×10^{-5} | 1.87×10^{-4} |
| TOTAL | | 12.12 | 9.0 | 3.12 |

^aNumbers may not add up across rows due to rounding considerations.

^bThese are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^cThese are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote b above.

^dDioxin/furan emission estimates from municipal waste combustors are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations. Emissions for 1995 are estimated to be 1.6 lb (U.S. EPA, 1996a).

^e1995 2,3,7,8-TCDD TEQ emissions are estimated to be 0.33 lb (U.S. EPA, 1996b).

^f1996 2,3,7,8-TCDD TEQ emissions are estimated to be 0.13 lb (Rizeq, 1997a).

^gNot applicable.

^hHouseholds for which the specified fuel is the primary heating source.

ⁱNumber of facilities consists of 24 that use PCP exclusively, and 15 that use both PCP and creosote.

^jDioxin/furan emission estimates from sewage sludge incinerators are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^k1996 2,3,7,8-TCDD TEQ emissions are estimated to be 0.049 lb (Rizeq, 1997b).

^l1996 2,3,7,8-TCDD TEQ emissions are estimated to be 0.007 lb (Rizeq, 1997a).

attributable to major sources and 3.12 lbs/yr to area sources. The leading individual sources categories emissions are:

- Municipal Waste Combustion - 62 percent
- Medical Waste Combustion - 11 percent
- Portland Cement Kilns: Hazardous Waste Fuels - 8.1 percent
- Residential Coal Combustion - 4.0 percent
- Secondary Aluminum Production - 3.3 percent
- Other Biological Incineration - 2.7 percent
- Utility Coal Combustion - 2.6 percent

This list of sources comprises over 93 percent of the national emissions total. In terms of the categories whose emissions are quantified in this study, 18 source categories are responsible for the remaining 7 percent of total national 2,3,7,8-TCDD TEQ emissions.

It should be noted that the estimate for municipal waste combustors (MWC) reflects the data point estimated by EPA for the 1993 time period. This value was selected for this report because based on the available data it is the closest in time to the desired baseline date of 1990. The 1993 data do not, however, reflect the significant control and dioxin emission reductions expected to occur as a result of the MWC MACT standards (U.S. EPA, 1996b).

There have been new mobile source data published since the release of the draft dioxin reassessment document in 1994. The EPA's Office of Research and Development has obtained this new information and is in the process of incorporating it into the next release of the dioxin document, thus updating most emission factors and their relative importance as a dioxin/furan source. At the time that ORD completes its analysis of the new mobile source data, the information contained in this inventory will also be updated.

Figure 4-1 graphically presents the relative contributions of the source categories to 1990 national 2,3,7,8-TCDD TEQ emissions.

4.3.2 Major/Area Source Emissions

Allocation of the national emissions to major and area sources was determined for each source category as shown in Tables 4-2, 4-3, and 4-4. The dominant major source categories are MWCs (77 percent of major source emissions), Portland cement kilns burning hazardous waste (11 percent), utility coal combustion (3.3 percent), medical waste incinerators (2 percent), and secondary aluminum production (2 percent). The leading contributors to area source emissions are medical waste incinerators (36 percent of area source emissions), residential coal combustion (15 percent), municipal waste combustion (12 percent), other biological incineration (10 percent), forest fires (6.1 percent), and secondary aluminum production (6.1 percent).

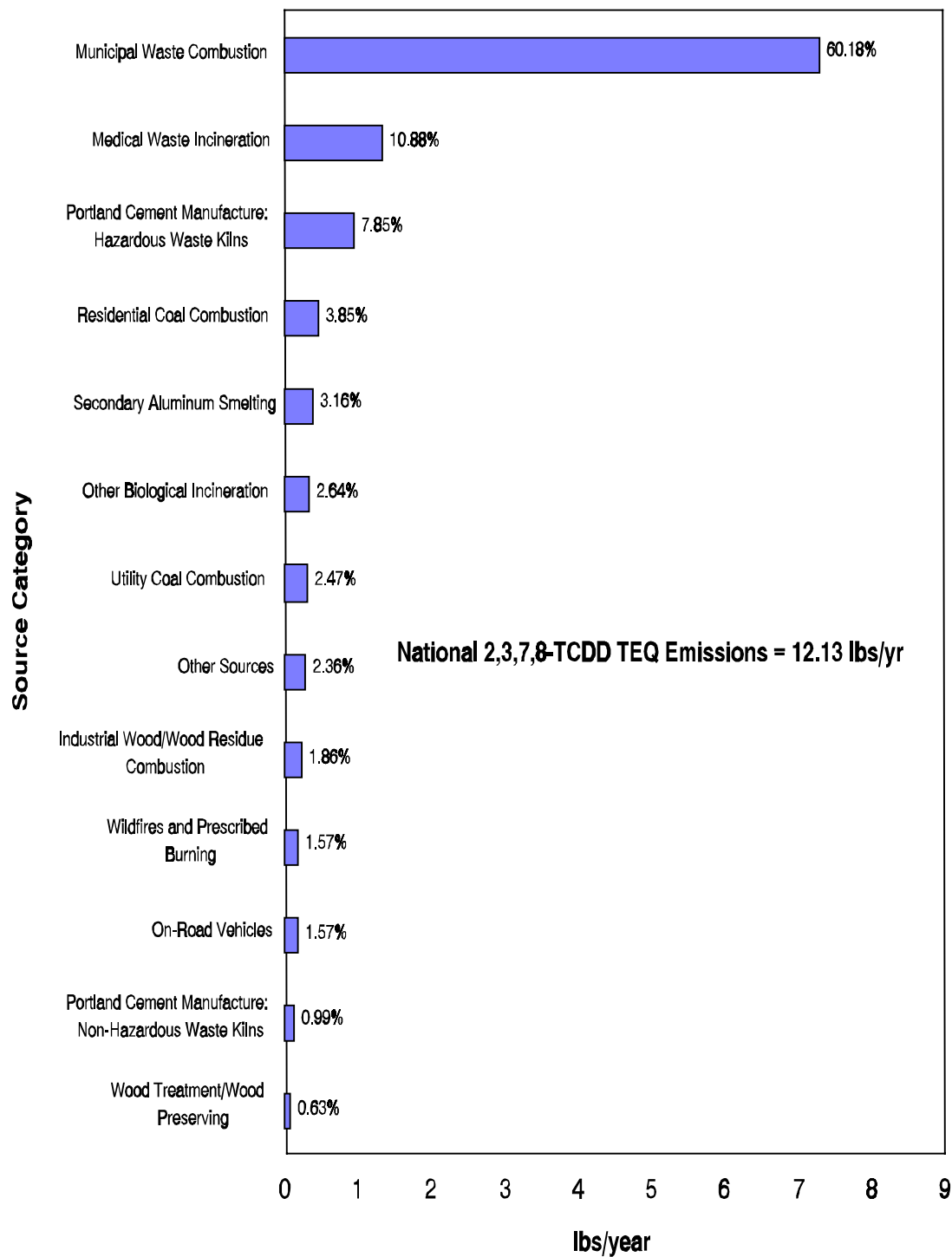


Figure 4-1. Relative Source Category Contribution to 1990 National 2,3,7,8-TCDD TEQ Emissions

4.4 References

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5.0 EMISSION ESTIMATES FOR POLYCHLORINATED BIPHENYL COMPOUNDS (PCBs)

5.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with developing the national inventory of PCB emissions. More detailed descriptions of inventory development procedures are available in Appendix A and in the following documents: "Memorandum for Inventory Plan for Section 112(c)(6) Pollutants" (Mangino et al., 1993) "Memorandum for Status of PCB Data Search and Analysis," (Elmore et al., 1993), and the OHEA Report Estimating Exposures to Dioxin-Like Compounds, Volume II: Properties, Sources, and Occurrence and Background Exposures (U.S. EPA, 1994). Table 5-1 summarizes the methodology and assumptions used to estimate emissions for each source category. The table contains a listing of the national activity data, emission factors, major source/area source distributions, and urban/rural allocation methods used for each PCB category.

There are 209 possible PCB congeners that can be created (U.S. EPA, 1987). The toxicity of a particular PCB is affected by the number and position of the chlorine molecules attached to the biphenyl. Some PCB species (i.e., some coplanar and monortho coplanar PCBs) have recently been identified as "dioxin-like" that have relative toxicities 100-1000 times higher than those associated with other PCB congeners (U.S. EPA, 1993). Because of the range in toxicities between the different PCB congeners, an attempt was made to identify emissions and activity data for individual PCB species that could be used to develop national PCB emissions. Unfortunately, very little information is available on emissions of the individual PCB congeners. Therefore, emission estimates for PCBs are reported here as "total PCBs," and individual congener emissions are not presented. All emission estimates are reported as annual values representative of the 1990 base year, unless noted otherwise.

Table 5-1

**National Activity, Emission Factors, and Allocation
Assumptions for PCB Source Categories^a**

| Source Category | 1990 National Annual Activity Level | Emission Factor | Major/Area Assumptions (%) of Source ^b |
|--|---|---|---|
| INCINERATION SOURCES | | | |
| Municipal Waste Combustion | 32.0 million tons of municipal waste incinerated | 5.5×10^{-6} lb/ton waste incinerated | 95/5 |
| Medical Waste Incineration | 1.73 million tons of medical waste incinerated | 4.65×10^{-5} lb/ton waste incinerated | 15/85 |
| Other Biological Incineration | 117,900 tons biological waste per year incinerated | 4.65×10^{-5} lb/ton waste incinerated | 0/100 |
| Sewage Sludge Incineration | 953,200 tons dry sludge incinerated | 1.08×10^{-5} lb/ton dry sludge incinerated | 0/100 |
| Hazardous Waste Incineration | 2.78×10^4 tons of PCBs incinerated | 2.0×10^{-3} lb/ton PCB incinerated | 100/0 |
| Scrap Tire Incineration | 551,000 tons tires incinerated | 3.78×10^{-6} lbs/ton tire incinerated | 100/0 |
| STATIONARY EXTERNAL FUEL COMBUSTION | | | |
| Utility Residual Fuel Oil Combustion | 181 million barrels residual fuel consumed (3.04×10^5 lbs of PCBs burned) | 1 lb/ 10^6 lb PCB burned | 90/10 |
| Industrial Residual Fuel Oil Combustion | 66 million barrels residual fuel consumed (1.1×10^5 lbs of PCBs burned) | 1 lb/ 10^6 lb PCB burned | 70/30 |

^aThe derivation of the emissions data and assumptions presented in this table are explained in detail in Mangino et al., 1993.

^bThe term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.

A toxic equivalent approach for PCBs has been used in a way similar to that used for chlorinated dioxins and furans, but only for those PCBs having "dioxin-like" toxicological properties (Safe, 1992). Because information was not available to inventory PCB congeners individually, and because "dioxin-like" PCBs are only a fraction of all PCBs, this toxic equivalency approach was not used in this report.

5.2 Source Category Inclusion

The PCB-emitting source categories were identified based on an in-depth review of available literature sources and on previously developed national inventories. National emissions estimated were developed for all source categories with documented emission factors or credible national emissions estimates. Table 5-1 identifies the categories for which national emissions estimates were developed.

The following source categories were identified as potential sources of PCB emissions for which sufficient data could not be determined to develop credible national emissions estimates:

- Treatment, Storage, and Disposal Facilities (TSDFs);
- Landfills;
- Superfund Sites;
- Steel and Iron Reclamation (Auto Scrap Burning);
- Accidental Releases (PCB spills and leaks and transformer fires); and
- Environmental Sinks of Past PCB Contamination.

Emissions of PCBs were not determined from TSDFs and landfills due to a lack of PCB emission factors. Secondary steel and iron reclamation may be a limited PCB emission source. National PCB air emissions were not determined from this source because a large portion of automobile scrap is not incinerated, and emission factors were not available.

Activity data for accidental PCB spills and transformer fires are not currently available. It was determined that the spill database maintained by the National Response Center did not provide reasonable activity data. Environmental media contaminated with past PCB releases is also a source of PCB emissions. National PCB emissions from contaminated lakes and sediments were not estimated due to the large number of water bodies in the United States, and the probable variation in both PCB contamination levels and emission rates that would lead to very low confidence in any national or regional scale emission estimates.

5.3 Detailed Emissions Summary

This section presents detailed PCB emissions estimate information on a total national and major/area source basis for the 1990 base year.

5.3.1 National Emissions

National emission estimates 1990 for each source category and subcategory were developed using one of two basic approaches. The first, and preferred, approach was to utilize emissions estimates developed by the EPA's OAQPS project teams in charge of developing MACT standards, or other EPA projects where in-depth evaluation and characterization of the source categories was conducted. National PCB emissions estimates have not been developed previously by the EPA for any particular source category. The second or alternative approach was to combine category-specific national activity data (i.e., throughput, production, and fuel use) with emission factors and available information on industry characteristics and control levels to develop national emissions estimates. The availability and overall quality of national activity data vary by category. Preferred sources of national activity data are trade associations and statistics compiled by government agencies such as the EPA and the Department of Energy. Emission factors derived from source tests were used wherever possible. An attempt was made to utilize emission factors that reflect the standard emission control methods used by each source category in 1990.

Table 5-2 presents the estimated 1990 base year national emissions of PCB for each source category. The source categories are presented in the order of their contribution to total emissions. All of the PCB source categories are currently listed in the EPA's Section 112 list of major sources (Federal Register, 1992). The total national emissions are presented as well as apportioned to source definitions as "major" or "area." Also presented in Table 5-2 are the estimated number of facilities or units (e.g., number of incinerators) within each source category. The numbers of facilities and units are, for the most part, crude estimates that provide some indication of the population within each category and therefore provide some insight into the size of the population that may need to be regulated.

Figure 5-1 identifies the contribution of specific source categories to total 1990 national emissions. Municipal waste combustion, hazardous waste incineration, and medical waste incineration contribute over 95 percent of national PCB emissions. Municipal waste combustion contributes the largest percentage (51 percent), followed by medical waste incineration (26 percent), and hazardous waste incineration (18 percent). All other categories combined contribute less than 6 percent of national PCB emissions.

5.3.2 Major/Area Source Emissions

Of the national total, 71 percent is attributed to major sources. Municipal waste combustion is the dominant major source contributor (69 percent of major source emissions). Hazardous waste incineration and medical waste incineration contribute 25 and 5.4 percent, respectively, to the major source total. The category with the greatest quantity of area source emissions is medical waste incineration (68.4 lbs/year). It constitutes 75 percent of the area source total. The bulk of the remaining area source emissions are attributable to sewage sludge incineration (11 percent) and municipal waste combustion.

This inventory indicates that area sources contribute less than 30 percent of national PCB emissions. Area source emissions, however, may not be well represented in this inventory. In general, activity data are much less available for PCB emissions sources which

Table 5-2

**National 1990 Base Year PCB Emissions and Distribution
on a Major/Area Source Basis^a**

| Source Category | Number of Facilities | Total National Emissions (lb/year) | Percent Contribution (%) | Major Source Emissions (lb/year) ^b | Area Source Emissions (lb/year) ^c |
|--|----------------------|------------------------------------|--------------------------|---|--|
| Municipal Waste Combustion | 158 | 161 | 51 | 153 | 8 |
| Medical Waste Incineration | 3,400 | 80.5 | 26 | 12.1 | 68.4 |
| Hazardous Waste Incineration | 150 | 55.5 | 18 | 55.5 | 0 |
| Sewage Sludge Incineration | 174 | 10.3 | 3.3 | 0 | 10.3 |
| Other Biological Incineration | 1,700 | 5.0 | 1.6 | 0 | 5.0 |
| Scrap Tire Incineration | 18 | 2.1 | 0.7 | 2.1 | 0 |
| Utility Boilers - Residual Oil Combustion | 545 | 0.3 | 0.1 | 0.27 | 0.03 |
| Industrial Boilers - Residual Oil Combustion | 6,000 | 0.1 | <0.01 | 0.08 | 0.02 |
| TOTAL | | 314.8 | 100 | 223.1 | 91.7 |

^aAppendix A contains documentation on the derivation of all emission estimates.

^bThese are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^cThese are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote b above.

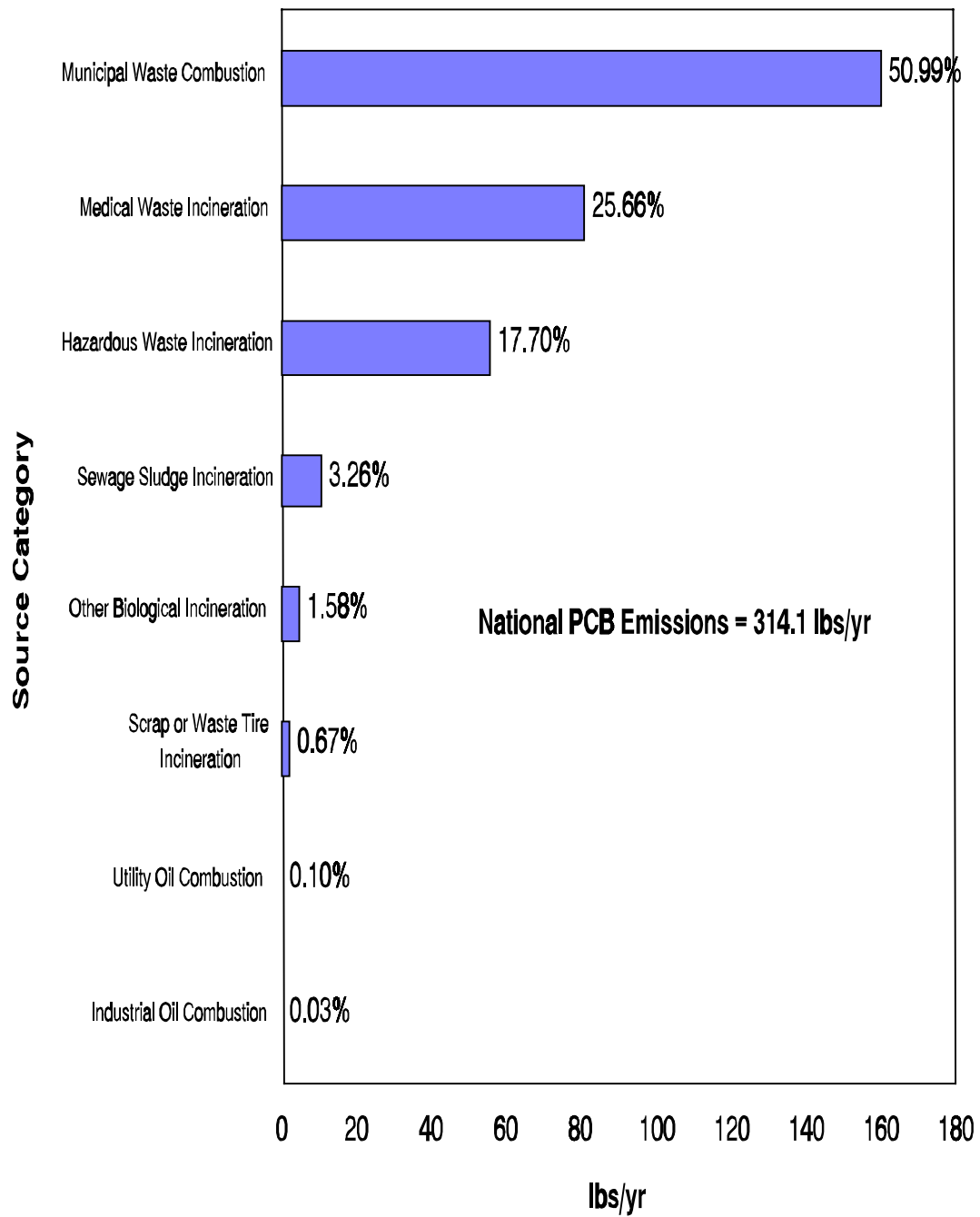


Figure 5-1. Percentage Contribution to 1990 National PCB Emissions by Source Category

are primarily composed of area sources rather than major sources (for example, PCB fires and accidental releases).

5.4 References

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6.0 EMISSION ESTIMATES FOR MERCURY

6.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with the development of a national inventory of mercury emissions. All of the emission estimates and information on mercury sources were obtained directly from the document Mercury Study Report to Congress. Volume II: An Inventory of Anthropogenic Mercury Emissions in the United States, (U.S. EPA, 1996a), and other EPA sources (Rizeq, 1997a; Rizeq, 1997b). This document was prepared by the EPA's OAQPS and ORD in order to fulfill 1990 CAAA requirements to produce a Report to Congress (RTC) on mercury emissions (U.S. EPA, 1996a). The reader is strongly encouraged to consult the RTC document to obtain more in-depth knowledge of mercury sources and emissions.

The methodologies and assumptions used to determine emissions for each source category are presented in Table 6-1. The table contains a listing of the number of facilities, national activity data, basis for the emissions estimates, and the major source/area source distribution used for each source category. It should be noted that for most source categories, the numbers of facilities are rough approximations, but they are useful in providing some indication of the population within each category, and therefore, some insight into the size of the population that may need to be evaluated for possible regulation.

The base years for the national mercury emissions estimates presented in the RTC are 1990-1993, with the exception of the estimate provided for hazardous waste combustors. There were insufficient data to estimate 1990 emissions for this category, but an estimate for 1995 was available and it is presented in the RTC. For convenience, throughout this chapter, emissions for the 1990-1993 period are referred to as 1990 base year emissions.

Table 6-1

**Number of Facilities, National Activity, Basis for Emissions Estimates and
Major/Area Distributions for Mercury Emissions Source Categories^a**

| Source Category | Number of Facilities | 1990 National Annual Activity Level | Basis for Emissions Estimate | Major/Area Assumptions (%) of Source ^b |
|--|----------------------|---|--|---|
| Medical Waste Incinerators | 3,400 | 1.73 x 10 ⁶ tons of medical waste incinerated ^c | All estimates are from the EPA NESHAP program. Model plants representing the different incinerator configurations in use were used to derive national estimate. ^c | 15/85 |
| Municipal Waste Combustors | 158 | 32.7 x 10 ⁶ tons, assuming all plants operate at 85% design capacity | Emission factor * activity level method | 95/5 |
| Utility Boilers - Coal Combustion | 1,201 | 1.6 x 10 ¹⁶ Btu heat input | Mercury concentration in fuel * emission modification factors based on boiler/control configurations * national activity levels for each boiler/control configuration | 100/0 |
| Utility Boilers - Oil Combustion | 545 | 1.2 x 10 ¹⁵ Btu heat input | Mercury concentration in fuel * emission modification factors based on boiler/control configurations * national activity levels for each boiler/control configuration | 90/10 |
| Utility Boilers - Natural Gas Combustion | 545 | 2.8 x 10 ¹⁵ Btu heat input | Mercury concentration in fuel * emission modification factors based on boiler/control configurations * national activity levels for each boiler/control configuration | 90/10 |

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

| Source Category | Number of Facilities | 1990 National Annual Activity Level | Basis for Emissions Estimate | Major/Area Assumptions (%) of Source ^b |
|---|----------------------|--|---|---|
| Commercial/industrial Boilers - Coal Combustion | Not available | Bituminous/lignite- 2.82×10^{15} Btu heat input; anthracite- 2.18×10^{13} Btu heat input | Emission factor * activity level method; uncontrolled emission factors- 16 lb/10 ¹² Btu for bituminous/lignite, 18 lb/10 ¹² Btu for anthracite | 70/30 |
| Commercial/Industrial Boilers - Oil Combustion | Not available | 1.67×10^{15} Btu heat input, distillate and residual | Emission factor * activity level method; Uncontrolled emission factors- 6.8 lb/10 ¹² Btu for residual, 7.2 lb/10 ¹² Btu for distillate | 70/30 |
| Residential Boilers - Coal Combustion | Not available | Bituminous/lignite- 4.34×10^{13} Btu heat input; Anthracite- 1.83×10^{13} Btu heat input | Emission factor * activity level method; Uncontrolled emission factors- 16 lb/10 ¹² Btu for bituminous/lignite, 18 lb/10 ¹² Btu for anthracite | 0/100 |
| Residential Boilers - Oil | Not available | Distillate and residual- 8.38×10^{14} Btu heat input | Emission factor * activity level method; uncontrolled emission factors- 6.8 lb/10 ¹² Btu for residual, 7.2 lb/10 ¹² Btu for distillate | 0/100 |
| Sewage Sludge Incinerators | 174 | 1.65×10^6 tons | Emission factors for each control type * percent of population for each control type * activity level; emission factors- 3.5×10^{-5} lb/ton for venturi and impingement scrubbers, 3.25×10^{-5} lb/ton for other controls; percent of population- 32.6% for venturi and impingement scrubbers, 67.4% for other controls | 0/100 |

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

| Source Category | Number of Facilities | 1990 National Annual Activity Level | Basis for Emissions Estimate | Major/Area Assumptions (%) of Source ^b |
|--|----------------------|---|--|---|
| Crematories | 395 | 400,465 cremations | Emission factor * activity level method; emission factor- 2.06×10^{-6} lb/cremation ^d | 0/100 |
| Wood-fired Boilers (Non-residential) | 45,150 | National capacity of wood-fired boilers- 1.04×10^{11} Btu/hr | Emission factor * heating value * operating hours/year * activity level; Emission factor- 0.67×10^{-5} lb/ton, heating value - 4,560 Btu/lb; operating hours/year - 8,760 | 80/20 |
| Hazardous Waste Incinerators ^e | 150 | 1.43×10^6 tons of waste burned | Estimate provided by EPA/Office of Solid Waste (OSW), based on measured data and extrapolations of the measured data to similar facilities in the source category. | 100/0 |
| Lightweight Aggregate Kilns | 5 | Not available | Estimate provided by EPA/OSW, based on measured data and extrapolations of the measured data to similar facilities in the source category. | 100/0 |
| Primary Lead Smelters | 3 | Activity data not used to estimate emissions | Information received from facilities and input from EPA's metals group | 100/0 |
| Secondary Mercury Production | 5 | 371 tons produced | Emission factor * activity level method; emission factor- 40 lb/ton | 50/50 |
| Chlor-alkali Production | 13 | Activity data not used to estimate emissions | Section 114 responses | 30/70 |
| Portland Cement Kilns: Non-Hazardous Waste | 90 | 67.6 million tons clinker produced ^f | Emission factor activity level method; emission factor- 1.5×10^{-4} lb/ton clinker produced ^f | 80/20 |

Table 6-1

**Number of Facilities, National Activity, Basis for Emissions Estimates and
Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)**

| Source Category | Number of Facilities | 1990 National Annual Activity Level | Basis for Emissions Estimate | Major/Area Assumptions (%) of Source ^b |
|--|----------------------|--|--|---|
| Portland Cement Kilns: Hazardous Waste | 20 | Approximately 1×10^6 tons of waste burned | Estimate provided by EPA/OSW, based on measured data and extrapolations of the measured data to similar facilities in the source category. | 100/0 |
| Primary Copper Production ^g | 8 | Not available | Section 114 responses summarized by EPA's Metals Group | 100/0 |
| Lime Manufacturing | >10 | Not available | Emission factor * activity level method; emission factor- 1.22×10^{-4} lb/ton lime produced | 50/50 |
| Electrical Apparatus Manufacturing | Not available | 116 tons mercury used | Emission factor * activity level method; emission factor- 8 lb/ton mercury used | 0/100 |
| Instrument Manufacturing | Not available | 57 tons mercury used | Emission factor * activity level method; emission factor- 18 lb/ton mercury used | 0/100 |
| Carbon Black Production | 24 | 1.7×10^6 tons capacity | Emission factor x activity level method; emission factor- 3×10^{-4} lb/ton carbon black produced | 30/70 |
| Fluorescent Lamp Recycling | Not available | Not available | Emission factor * activity level method; emission factor-1 lb/100 lbs mercury recycled | 0/100 |
| Battery Production | 16 | 18 tons mercury used in battery production | Emission factor * activity level method; emission factor- 2 lb/ton mercury used | 0/100 |

Table 6-1

**Number of Facilities, National Activity, Basis for Emissions Estimates and
Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)**

| Source Category | Number of Facilities | 1990 National Annual Activity Level | Basis for Emissions Estimate | Major/Area Assumptions (%) of Source ^b |
|-------------------------------|----------------------|-------------------------------------|---|---|
| Geothermal Power | 18 | 2,628.4 megawatts of capacity | Emission factor * activity level method; emission factors: off-gas ejectors- 0.00002 lb/MWe/hr, cooling tower exhaust- 0.0001 lb/MWe/hr | 0/100 |
| Lamp Breakage | Not available | Not available | Mass balance and engineering judgement | 0/100 |
| General Laboratory Activities | Not available | 20 tons mercury used | Emission factor * activity level method; emission factor- 80 lb/ton mercury used | 0/100 |
| Dental Preparation and Use | Not available | 41 tons mercury used | Emission factor * activity level method; emission factor- 2 lb/100 lb mercury used | 0/100 |

^aActivity and emission factor data are from U.S. EPA, 1996, unless indicated otherwise, and were used to estimate annual emissions for 1990-1993.

^bThe term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.

^cCopeland, 1996.

^dCamellia Cemetary, 1992.

^eEmission estimate for this category represents emissions from dedicated hazardous waste incinerators. It does not include emissions from BIFs. Separate estimates are provided for Portland cement kilns and light weight aggregate kilns burning hazardous waste. No estimates were available for other BIFs (e.g., boilers or smelting furnaces).

Table 6-1

**Number of Facilities, National Activity, Basis for Emissions Estimates and
Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)**

^fHeath, 1996.

^gEPA and a number of state agencies are currently evaluating the major/area source allocation for this source category. This preliminary allocation is being used for inventory purposes only.

The EPA used an emission factor-based approach to estimate national mercury emissions for most source categories in the RTC. This approach requires a source-specific emission factor and an estimate of the annual nationwide source activity to estimate emissions. There are uncertainties inherent in the emission factor-based approach that affect the accuracy of national emissions estimates. Quantitative estimates of the uncertainty in the emission factor-based approach are not available, although they can be discussed qualitatively. Ideally, emission factors are based on a substantial quantity of data from sources that represent the entire source category population. For trace pollutants like mercury, however, emission factors are frequently based on limited data that may not have been collected from sources that are representative of the entire source category. In addition, changes over time in processes, pollution control systems, measurement techniques, and analytical methods may result in biased emission factors. Finally, the sources of data used to develop activity levels vary in reliability, adding further uncertainty to the emissions estimates. (U.S. EPA, 1996a).

Other approaches used by the EPA to develop the emissions estimates presented in the RTC include engineering judgment, mass balance, and data obtained directly from industries. As with the emission factor-based approach, the accuracy and representativeness of the data used will affect the uncertainties of emissions estimates.

6.2 Source Category Inclusion

The mercury RTC discussed above was the primary reference used to identify the source categories of mercury emissions that are presented in this document. The RTC was prepared in response to the mandate listed in the CAAA that requires EPA to submit a study on atmospheric mercury emissions to Congress. The RTC consists of a seven-volume study. Volume II of the RTC presents source categories of mercury emissions and provides annual mercury emissions estimates, abbreviated process descriptions, control technique options, emission factors, and activity levels for these sources. The EPA relied on various emission studies that they have conducted to identify the source categories of mercury emissions presented in the RTC.

The RTC identifies several potential source categories of mercury emissions for which data were not sufficient to develop national emissions estimates. For example, mercury has been identified as a constituent of landfill gas emissions, but emission factors have not yet been developed that can be used to estimate national emissions. The categories identified in the RTC and elsewhere as probable or known mercury emissions sources but for which estimates could not be formulated are:

- Mobile Sources;
- Agricultural Burning;
- Boilers and Industrial Furnaces burning hazardous waste (excluding Portland cement kilns and light weight aggregate kilns burning hazardous waste);
- Landfills;
- Primary Mercury Production;
- Mercury Compounds Production;
- Byproduct Coke Oven Batteries;
- Petroleum Refining; and
- Natural Sources (oceanic, terrestrial, vegetative).

6.3 Detailed Emissions Summary

This section presents detailed 1990 base year mercury emissions information on a total national and major/area basis.

6.3.1 National Emissions

Table 6-2 presents the 1990 base year national emissions estimates of mercury for each source category. The source categories are presented in the order of their contribution to total emissions. Municipal waste combustion, coal-fired utility boilers, and medical waste incinerators account for 69 percent of the total emissions. Municipal waste combustion contributes 24 percent of the total emissions, followed by coal-fired utility boilers at 23 percent and medical waste incinerators with roughly 22 percent.

Figure 6-1 identifies the contribution of specific source categories to total national 1990 base year emissions.

Current emissions for several of these source categories (e.g., MWCs, cement kilns, and MWIs) are significantly below the 1990 levels shown here due to the development and application by EPA of various MACT standards. For these source categories, the 1990 estimates are not representative of the reduced contributions these categories are making to current national emission levels.

6.3.2 Major/Area Source Emissions

Using the allocation assumptions described in 2.0, mercury emissions were grouped, by source category, as to whether they originated from major or area sources. As shown in Table 6-2, 67 percent of the total mercury emissions are attributable to major sources, with the remaining 33 percent coming from area sources. Mercury emissions from municipal waste combustors account for 35 percent (104,500 pounds) of the major source emissions. Coal-fired utility boilers contribute the next largest amount of major source emissions with 34 percent (102,000 pounds), followed by coal-fired commercial/industrial boilers with 11 percent (31,920 pounds). Medical waste incinerators are the largest source of area emissions, accounting for 57 percent (85,000 pounds) of the total area emissions. The next largest sources of area emissions are coal-fired commercial/industrial boilers with 9 percent (13,680 pounds) and chlor-alkali production with 6 percent (8,960 pounds).

Table 6-2

**National 1990 Base Year Mercury Emissions Estimates and
Major/Area Source Distributions^a**

| Source Category | Total National Emissions (lb/year) | Major Source Emissions (lb/year) ^b | Area Source Emissions (lb/year) ^c |
|--|------------------------------------|---|--|
| Municipal Waste Combustion ^d | 110,000 | 104,500 | 5,500 |
| Utility Boilers - Coal Combustion | 102,000 | 102,000 | 0 |
| Medical Waste Incinerators ^e | 100,000 | 15,000 | 85,000 |
| Commercial/Industrial Boilers - Coal Combustion | 45,600 | 31,920 | 13,680 |
| Secondary Mercury Production | 14,800 | 7,400 | 7,400 |
| Chlor-alkali Production ^f | 12,800 | 3,840 | 8,960 |
| Commercial/Industrial Boilers - Oil Combustion | 12,000 | 8,400 | 3,600 |
| Portland Cement Kilns: Non-Hazardous Waste | 10,000 ^g | 8,000 | 2,000 |
| Portland Cement Kilns-Hazardous Waste ^h | 7,000 | 7,000 | 0 |
| Hazardous Waste Incinerators ^h | 6,392 | 6,392 | 0 |
| Residential Boilers - Oil Combustion | 6,000 | 0 | 6,000 |
| Primary Copper Production ⁱ | 3,790 | 3,790 | 0 |
| Sewage Sludge Incinerators | 3,600 | 0 | 3,600 |
| Lamp Breakage | 3,000 | 0 | 3,000 |
| Geothermal Power | 2,600 | 0 | 2,600 |
| Primary Lead Smelters ^j | 2,600 | 2,600 | 0 |

Table 6-2**National 1990 Base Year Mercury Emissions Estimates and
Major/Area Source Distributions^a (Continued)**

| Source Category | Total National Emissions (lb/year) | Major Source Emissions (lb/year) ^b | Area Source Emissions (lb/year) ^c |
|--|--|---|--|
| Dental Preparation and Use | 1,600 | 0 | 1,600 |
| General Laboratory Activities | 1,600 | 0 | 1,600 |
| Lime Manufacturing | 1,400 | 700 | 700 |
| Residential Boilers - Coal | 1,200 | 0 | 1,200 |
| Instrument Manufacturing | 1,000 | 0 | 1,000 |
| Electrical Apparatus Manufacturing | 920 | 0 | 920 |
| Wood-fired Boilers (Non-residential) | 600 | 480 | 120 |
| Lightweight Aggregate Kilns-Hazardous Waste ^h | 620 | 620 | 0 |
| Utility Boilers - Oil | 500 | 450 | 50 |
| Carbon Black Production | 500 | 0 | 500 |
| Battery Production | 40 | 0 | 40 |
| Fluorescent Lamp Recycling | 12 | 0 | 12 |
| Utility Boilers - Natural Gas | 4 | 4 | 0 |
| Crematories ^k | 0.82 | 0 | 0.82 |
| TOTAL | 452,179 | 303,096 | 149,083 |

Table 6-2

**National 1990 Base Year Mercury Emissions Estimates and
Major/Area Source Distributions^a (Continued)**

^aAll emissions estimates were obtained from U.S. EPA, 1996a and are 1990-1993 estimates, unless indicated otherwise.

^bThese are estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^cThese are estimated national emissions from "area" sources within the source category. "Area" sources are defined in this inventory as any source of HAPs that is not a major source.

^dEmissions for 1995 are estimated to be 29 tons (U.S. EPA, 1996b).

^eCopeland, 1996.

^fEC/R Inc., 1996.

^gHeath, 1996. Emission estimate is for emissions from kilns not burning hazardous waste as supplemental fuel.

^h1996 emissions are estimated to be:

| |
|---|
| 3.86 tons - Hazardous Waste Incinerators |
| 611 lbs - Lightweight Aggregate Kilns - Hazardous Waste |
| 2.93 lbs - Portland Cement Kilns - Hazardous Waste |

Reference: Rizeq, 1997a;
Rizeq, 1997b.

ⁱCrumpler, 1995. EPA and a number of state agencies are currently evaluating the major/area source allocation for this source category. This preliminary allocation is being used for inventory purposes only. The largest-emitting facility in this source category closed in 1995; total mercury emissions are now 110 lbs/yr from primary copper production.

^jCavender, 1996.

^kBased on activity data from reference U.S. EPA, 1996a and emission factor from reference Camellia Cemetery, 1992.

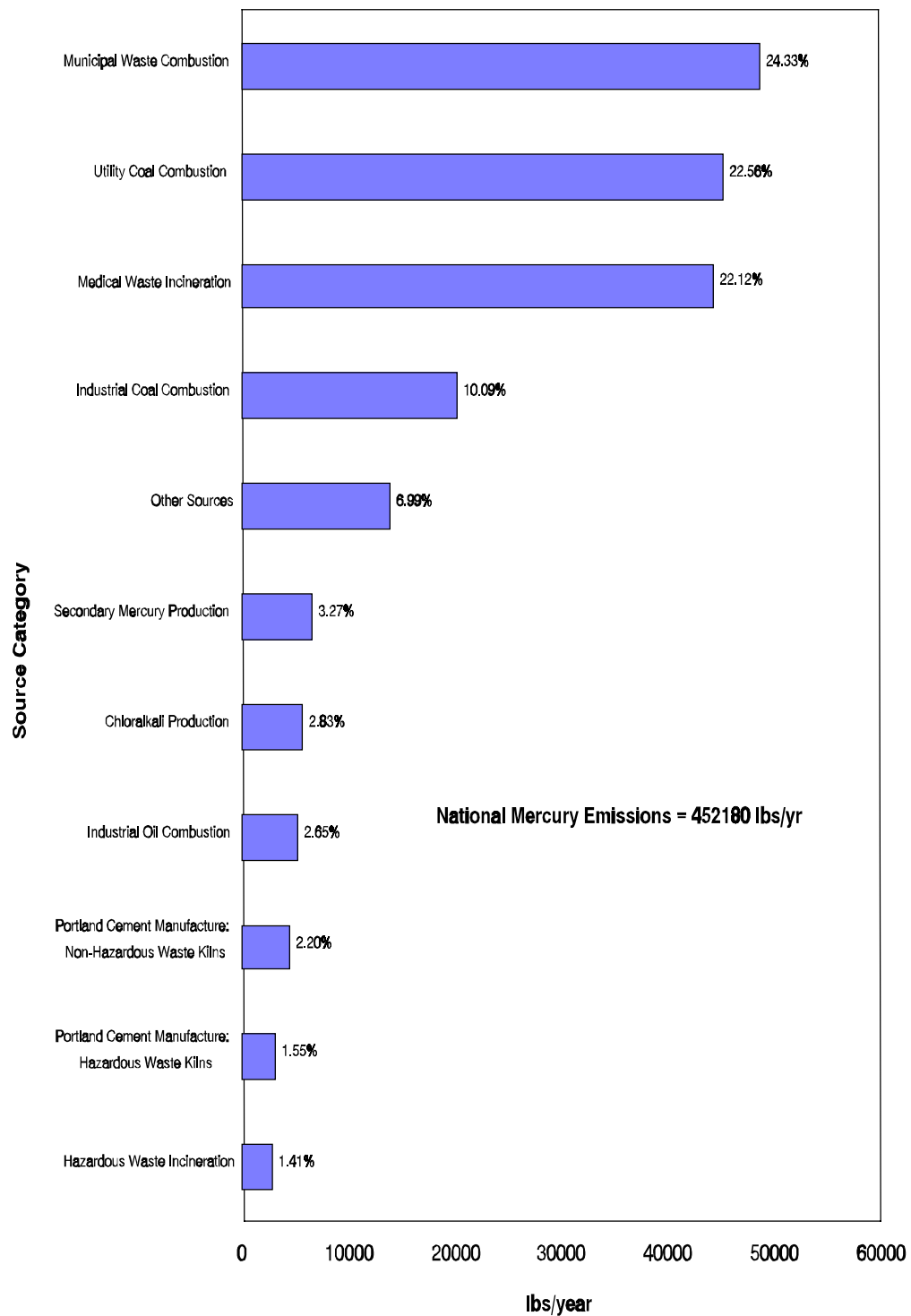


Figure 6-1. Percentage Contribution to 1990 National Mercury Emissions by Source Category

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7.0 EMISSION ESTIMATES FOR HEXACHLOROBENZENE

7.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with the development of a national inventory of hexachlorobenzene (HCB) emissions. All of the emission estimates and information on HCB sources, with the exception of pesticides application, were obtained directly from the document Estimation of National Hexachlorobenzene Emissions for 1990, Final Report prepared in 1993 by TRC Environmental Corporation for the U.S. EPA's Office of Air Quality Planning and Standards (OAQPS). This document was prepared by OAQPS to fulfill 1990 CAAA requirements to identify source categories emitting 90 percent of the total national HCB emissions (TRC, 1993). Estimates for pesticides application were generated from industry sources, published production statistics, and published data for the agricultural industry.

The source categories of HCB emissions that are identified in the TRC, 1993 document are chlorinated solvents production and pesticides manufacture. HCB is generated as an impurity during the manufacture of chlorinated solvents and pesticides, and is found in the air emissions from these processes. Also, because HCB is a pesticide contaminant, HCB is emitted when pesticides are applied to crops.

The methodologies and assumptions used to determine emissions for each source category of HCB emissions are presented in Table 7-1. The table contains a listing of the number of facilities, national activity data, basis for emissions estimates, and the major source/area source distribution used for each source category. It should be noted that for most source categories the numbers of facilities are rough approximations, but they are useful for providing some indication of the population within each category, and therefore, some insight into the size of the population that may need to be evaluated for possible regulation.

Table 7-1

**Number of Facilities, National Activity, Basis for Emissions Estimates and
Major/Area Distributions for Hexachlorobenzene Emissions Source Categories^a**

| Source Category | Number of Facilities | 1990 National Annual Activity Level | Basis for Emission Estimate | Major/Area Assumptions (%) of Source ^b |
|--|----------------------|---|---|---|
| Chlorinated Solvents Production ^c | 21 | 16,347 million pounds of chlorinated solvents produced | Extracted 1990 emissions data from TRI for facilities reporting to TRI, extrapolated data to facilities not reporting to TRI. | 100/0 |
| Pesticides Production ^d | 10 | Not available | TRI data | 100/0 |
| Pesticides Application ^{d,e} | Not available | Total pesticide use= 90,129, 653 lbs; available HCB=2,880 lbs | Speciation approach- Amounts of pesticide active ingredients used nationally X HCB% for each pesticide active ingredient (assume 8.4% of available HCB is volatilized as air emissions) | 0/100 |

^aAll data are from TRC, 1993, unless indicated otherwise.

^bThe term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.

^cIncludes the production of carbon tetrachloride, perchloroethylene, trichloroethylene, ethylene dichloride and 1,1,1-trichloroethane.

^dIncludes the pesticides atrazine, dimethyl tetrachloroterephthalate (DCPA), chlorothalonil, picloram, simazine, lindane, and pentachloronitrobenzene (PCNB).

^eGilding, 1996; Bailey, 1996; Parshley, 1996; Noble, 1996; McMaster, 1996; McMaster, 1997.

The TRC study used two methods to develop the emissions estimates presented in the OAQPS document. One approach consisted of examining the TRI system to identify facilities that emit HCB, and extracting the HCB emissions data for those facilities. The SRI Directory of Chemical Producers (SRI, 1990) then used to categorize the TRI facilities and to identify other facilities (non-TRI) that should be included in the source category. The TRI data were then extrapolated to the non-TRI facilities. This approach was used to estimate emissions from chlorinated solvents production.

The emissions estimate for pesticides manufacture was also developed from TRI data, but data were not available to extrapolate the emissions for TRI facilities to non-TRI facilities. Thus, the emissions estimate presented in the EPA HCB document for pesticides manufacture was developed from emissions data for TRI facilities only, and does not include emissions from facilities that do not report to TRI.

The emissions estimate for pesticides application was developed using a speciation approach. Emissions from pesticides application are the result of the volatilization of the active ingredients (AI), organic solvents, emulsifiers, and other organic compounds that may be used in formulation. Annual usage estimates of the leading AIs in pesticides were obtained and an estimate of the percentage of HCB of each AI was developed from data obtained from published literature and the industry. These data were combined to obtain an estimate of the amount of HCB contained in each pesticide. These data were then adjusted by the percent of HCB that has been shown in studies to be volatilized as air emissions. The volatilization rate is 8.4 percent. The data used to derive the pesticide application estimate are shown in Table 7-2.

There are some uncertainties in the approaches used by the EPA to estimate HCB emissions. As discussed above, the emissions estimate for pesticides manufacture was developed from TRI data only and does not include emissions from facilities not reporting to TRI. It is not known what effect these uncertainties have on the national

Table 7-2

Data Used to Derive 1990 HCB Emission Estimate for Pesticides Application^a

| Pesticide | Usage (lb/yr) | HCB Content (%) | HCB Available for Release (lb/yr) | % Volatilized | 1990 HCB Emissions (lb/yr) |
|----------------|---------------|-----------------|-----------------------------------|---------------|----------------------------|
| DACTHAL (DCPA) | 1,340,000 | 0.10 | 1,340.00 | 8.4 | 112.56 |
| Chlorothalonil | 11,566,093 | 0.005 | 578.30 | 8.4 | 48.58 |
| Picloram | 1,000,000 | 0.005 | 50.00 | 8.4 | 4.20 |
| Atrazine | 70,500,000 | 0.0001 | 70.50 | 8.4 | 5.92 |
| Simazine | 4,000,000 | 0.0001 | 4.00 | 8.4 | 0.34 |
| Lindane | 61,189 | 0.01 | 6.12 | 8.4 | 0.51 |
| PCNB | 1,662,371 | 0.05 | 831.19 | 8.4 | 69.82 |
| TOTAL | 90,129,653 | | 2,880.11 | | 241.93 |

^aGilding, 1996; Bailey, 1996; Parshley, 1996; Noble, 1996; McMaster, 1996; McMaster, 1997.

HCB emissions estimate, but it is probable that they result in an underestimate of emissions.

7.2 Source Category Inclusion

The EPA relied on the TRI database and emission studies that they have conducted to identify the source categories of HCB emissions presented in the 1993 document. All known or probable sources of HCB emissions are included in the document and national emissions estimates were developed for all source categories. Table 7-1 identifies the source categories of HCB emissions.

7.3 Detailed Emissions Summary

This section presents detailed HCB emissions information on a total national and major/area basis for a 1990 base year.

7.3.1 National Emissions

Table 7-3 presents the 1990 national emissions of HCB for each source category. As shown in the table, chlorinated solvents production accounts for 49 percent of the total HCB emissions, while pesticides manufacture and pesticides application account for 39 percent and 12 percent, respectively. Recent data from manufacturers indicate that current (1995-96) HCB emissions from pesticides application are less than 1990 levels or about 232 lb/yr (Gilding, 1996; Noble, 1996; McMaster, 1996; Parshley, 1996; Bailey, 1996).

Figure 7-1 illustrates graphically the contribution of specific source categories to total national emissions in 1990.

Table 7-3

**National 1990 Base Year Hexachlorobenzene Emissions Estimates and
Major/Area Source Distributions**

| Source Category | Total National Emissions (lb/year) | Major Source Emissions (lb/year) ^a | Area Source Emissions (lb/year) ^b |
|---------------------------------------|------------------------------------|---|--|
| Pesticides Application ^c | 292 ^{d,e} | 0 | 292 |
| Chlorinated Solvents Production | 1,161 ^f | 1,161 | 0 |
| Pesticides Manufacturing ^g | 915 ^f | 915 | 0 |
| TOTAL | 2,368 | 2,076 | 292 |

^aThese are estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^bThese are estimated national emissions from "area" sources within the source category. "Area" sources are defined in this inventory as any source of HAPs that is not a major source.

^cEmissions estimate is for the application of atrazine, simazine, picloram and dimethyl tetrachloroterephthalate.

^dGilding, 1996; Bailey, 1996; Parshley, 1996; Noble, 1996; McMaster, 1996.

^e1995-96 period emissions are estimated to be 232 lb/yr.

^fTRC, 1993.

^gEmissions estimate is only for facilities reporting to TRI, lindane, chlorothalonil, and pentachloronitrobenzene (PCNB).

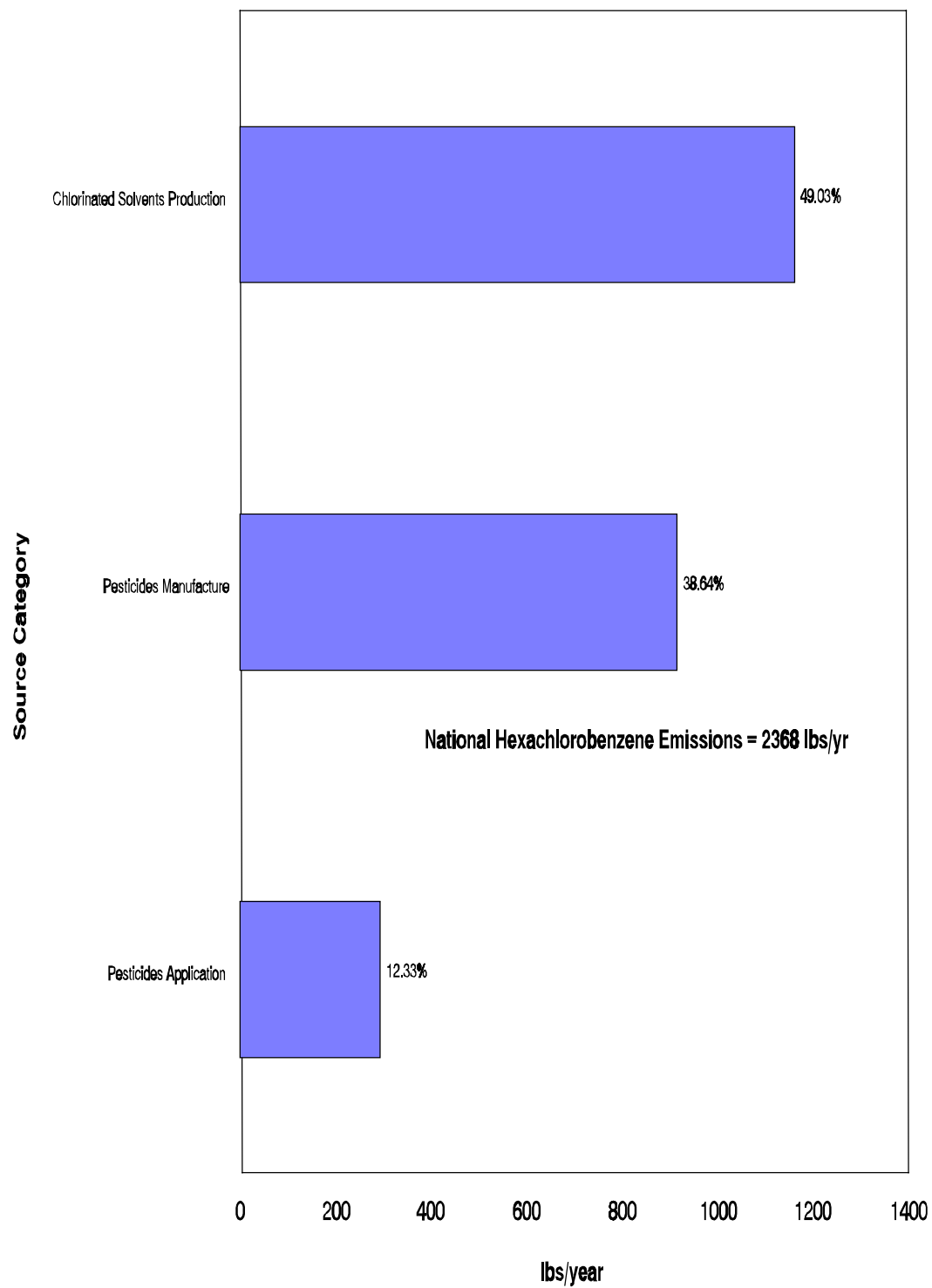


Figure 7-1. Percentage Contribution to 1990 National Hexachlorobenzene Emissions by Source Category

7.3.2 Major /Area Source Emissions

As shown in Table 7-3, HCB emissions from probable major sources account for 88 percent (2,076 pounds) of the total emissions, with the remaining 12 percent (292 pounds) coming from area sources. Emissions from pesticides application account for 100 percent of the area source total. Fifty-six percent (1,161 pounds) of the major source emissions are attributed to chlorinated solvents production, with the remaining 44 percent (915 pounds) coming from pesticides manufacture.

7.4 References

1. Bailey, Robert. Bailey Associates, letter to Anne Pope, U.S. Environmental Protection Agency. December 5, 1996.
2. Gilding, Thomas. American Crop Protection Association, letter to Laurel Driver, U.S. Environmental Protection Agency. November 27, 1996.
3. McMaster, Steve. DowElanco, letter to Laurel Driver, U.S. Environmental Protection Agency. November 27, 1996.
4. McMaster, Steve. DowElanco, letter to Laurel Driver, U.S. Environmental Protection Agency. January 20, 1997.
5. Nobeled, Edward, ISK Biosciences Corporation, letter to Laurel Driver, U.S. Environmental Protection Agency. November 26, 1996.
6. Parshley, Tom. Ciba-Geigy Corporation, letter and attachments to Laurel Driver, U.S. Environmental Protection Agency. November 27, 1996.
7. SRI. 1990 Directory of Chemical Producers. Menlo Park, CA, 1990.
8. TRC Environmental Corporation. Estimation of National Hexachlorobenzene Emissions for 1990, Final Report. Prepared under contract 68-D9-0173 for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. October 1993.

8.0 EMISSION ESTIMATES FOR ALKYLATED LEAD

Currently the only use for alkylated lead is as a fuel additive for piston engine combustion. Alkylated lead has been used in motor gasoline since the 1920s to boost octane and to provide lubrication for intake and exhaust valves. Alkylated lead antiknock compounds function by decomposing in the combustion cycle to form metal oxide particles. The particles interrupt the hydrocarbon chain branching reactions that cause rapid combustion, known as "knock." Alkylated lead antiknock compounds interfered with 1970 catalytic converter technologies developed to reduce hydrocarbon, carbon monoxide, and nitrogen oxides emissions. This led to the development of lead-free fuel in the early 1970s.

The lead levels in alkylated leaded gasoline have been gradually reduced from the industrial average of 5.5×10^{-3} lbs as lead per gallon of leaded gasoline in the 1970's to 4.4×10^{-7} lbs as lead per gallon of unleaded gasoline in 1991. Since 1982, the majority of gasoline fuel sold for motor vehicles has been lead free. Diesel fuel is assumed to contain quantities of alkylated lead that are insignificant compared to gasoline fuel. The fuel which currently has the greatest lead content is aviation gasoline (4.4×10^{-3} to 8.8×10^{-3} lbs as lead/gal). This fuel is not regulated under the 1990 CAAA.

The two most common lead antiknock additives are tetraethyl lead (TEL) and tetramethyl lead (TML). TEL and TML, both high in octane, lubricate intake and exhaust valves and help to reduce engine knock. In 1990, 93 percent of highway fuel lead additive was TEL, and the remaining 7 percent was TML.

Of the different aviation fuels currently in use, only aviation gasoline contains lead as an antiknock compound. There are two grades of aviation gasoline: low-lead, which has a lead concentration of 4.4×10^{-3} lbs lead per gallon of aviation gasoline, and high-lead, which has a lead concentration of 8.8×10^{-3} lbs lead per gallon of aviation gasoline. Only TEL is used in leaded aircraft fuel.

8.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with developing the national inventory of alkylated lead emissions. More detailed descriptions of inventory development procedures are available in Estimation of Alkylated Lead Emissions, Final Report prepared in 1993 by TRC for the EPA's OAQPS. This document was commissioned by OAQPS to fulfill 1990 CAAA requirements to identify source categories emitting 90 percent of the total national alkylated lead emissions (TRC, 1993).

The TRC report focuses on alkylated lead emissions from evaporative losses from marketing and distribution of leaded vehicle and aviation gasoline. The TRC study determined that it was impractical to calculate new evaporative loss emission factors using AP-42 equations because these equations require so much detailed data and assumptions about the individual source types, controls, fuel characteristics, and ambient conditions. These data were not readily available.

This problem was remedied by using emission factors from existing studies. The national gasoline marketing and distribution system has been studied previously in other EPA reports such as Gasoline Distribution Industry - Background Information for Proposed Standards Draft Report (U.S. EPA, 1992), Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry (U.S. EPA, 1984); and Draft Regulatory Impact Analysis: Proposed Refueling emission Regulations for Gasoline-Fuel Motor Vehicles - Volume I: Analysis of Gasoline Marketing Regulatory Strategies (U.S. EPA, 1987).

TRC obtained VOC emission factors from these reports for each of the source categories studied. The TEL and TML fractions of the VOC emissions were estimated using temperature-dependent weight fractions. These temperature-dependent weight fractions were based on the physical properties of the pure compounds (TEL, TML, and gasoline), the average lead content by weight of motor vehicle gasoline fuel in 1990 (1.87×10^{-4} lbs lead per gallon), and Antoine coefficients. The actual TEL/TML emission factors were

estimated by applying the alkylated lead vapor phase weight fraction to the gasoline VOC emission factor. The complete equations and calculations may be found in the TRC report (TRC, 1993).

State-level leaded gasoline sales data for 1990 which were provided by the Department of Energy were employed to calculate State-level emissions from gasoline distribution. In a few cases, where state-level gasoline sales were unavailable (e.g., pipelines), emissions were estimated based on the configuration (i.e., number of tanks, valves and seals) of a typical plant provided in the Gasoline Distribution Industry (Stage I) - Background Information for Proposed Standards document. These emissions were allocated to States based on the number of facilities reported in each state for the appropriate SIC code.

Aviation gasoline is transported directly from refineries to the airport terminal, which are assumed to represent the bulk plant. The aviation gasoline is then transported to the aircraft via small tank trucks. No emission factors specific to aircraft refueling were identified, so motor vehicle refueling emission factors were used because the operations are similar. Emissions from aviation gasoline distribution are likely to be uncontrolled due to the relatively low volatility of aviation gasoline. No factors were identified in the TRC report to estimate evaporative emissions from the plane's fuel tank after refueling.

One underlying assumption in the TRC report is that VOC emissions from unleaded and leaded fuels would be of the same general magnitude. This assumption is of concern as lead additives in gasoline were replaced by high octane hydrocarbon fractions. For example, aromatics, isoparaffins, and olefins produced from catalytic cracking and reforming processes can be blended with unleaded low octane straight-run refinery products to elevate the octane numbers of the unleaded fuel. As the concentration of aromatics are increased in unleaded gasoline, the VOC content of the fuel increases.

Table 8-1 summarizes the methodology and assumptions used to determine emission estimates for each source category identified as an emitter of alkylated lead. The table

contains a listing of the number of facilities, national activity data, basis for emissions estimates, and the major source/area source distribution used for each category. It should be noted that estimates for the number of facilities and units are, for the most part, rough estimates but they are useful for providing some indication of the population within each category and therefore some insight into the size of the population that may need to be evaluated for possible regulation.

8.2 Source Category Inclusion

Alkylated lead source categories were identified based on an in-depth review of available literature sources and previously developed national emissions inventories. National emissions estimates were developed for all source categories with documented emission factors or with credible emission inventories. Table 8-1 identifies the categories for which national emissions estimates were determined.

The following categories were identified as potential sources of alkylated lead emissions for which sufficient data were not available to develop credible national emissions estimates:

- Evaporative Emissions from Operations of Aircraft;
- Evaporative Emissions from Operations of Onroad Vehicles; and
- Alkylated Lead Production.

At this time it is not possible to discern quantitatively how significant the above sources are, but considering the amount of alkylated lead in aviation fuel, evaporative and combustion emissions from aircraft may be the most significant alkylated lead source.

Table 8-1
Number of Facilities, National Activity, and Major/Area Distribution
for Alkylated Lead Source Categories^a

| Source Category | Number of Facilities | 1990 National Annual Activity Level (Gallons) | Basis for Emission Estimate | Major/Area Assumptions (%) of Source ^b |
|--------------------------------------|----------------------|---|--|---|
| Bulk Plants - Aviation Gasoline | c | 322,629,000 ^d | VOC emission factors were used for motor vehicle fuel bulk plants. Temperature-dependent TEL weight fraction of VOC emission factors were developed assuming a lead content of 4 grams/gallon. The TEL emission factors were applied to 1990 State aviation gasoline data. | 0/100 |
| Non-road Vehicles Evaporative | e | e | TEL and TML emission factors based on population of equipment type and usage for 4 and 2 stroke gasoline engines. Emissions were not allocated to state-level. | 0/100 ^f |
| Service Stations | 387,750 | 1,363,508,750 ^d | TEL and TML emission factors derived from temperature-dependent weight fraction of VOC emission factors. The TEL and TML emission factors were applied to 1990 leaded gasoline sales. | 0/100 |
| Bulk Plants - Motor Vehicle Gasoline | 12,600 | 1,363,508,750 ^d | | 0/100 |
| Bulk terminals | 748 | e | | 27/73 |
| Pipelines | 79,624 miles | e | Based on emissions from national plant inventory as quantified in other EPA studies, disaggregated to states by SIC. | 0/100 |

^aAll data are taken from TRC, 1993. The derivation of the emission data and assumptions presented in this table are explained in detail in that report.

Table 8-1

**Number of Facilities, National Activity, and Major/Area Distribution
for Alkylated Lead Source Categories^a (Continued)**

^bThe term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.

^cAs aviation fuel is delivered directly from refineries to airports, the airports are considered to be bulk plants.

^dSee Appendix J of TRC, 1993.

^eThe data used to estimate emissions could not be summarized in this table. Refer to TRC, 1993.

^fMobile area sources.

8.3 Detailed Emissions Summary

This section presents detailed alkylated lead emissions information on a total national and major/area basis for a 1990 base year.

8.3.1 National Emissions

Total national 1990 base year emissions of TEL and TML are 810.6 lb of TEL per year and 481.23 lb of TML per year as shown in Table 8-2. The source categories are presented in the order of their contribution to total emissions. Aviation gasoline bulk plants (airport terminals) proportionally dominated the TEL evaporative emission inventory representing 92 percent of national TEL emissions. Non-road engines and vehicles proportionably dominate the TML evaporative emission inventory representing 61 percent of national TML emissions.

8.3.2 Major/Area Source Emissions

As shown in Table 8-2, greater than 99.9 percent of total estimated TEL and TML emissions are considered area source emissions. Figure 8-1 identifies the contribution of specific source categories to total national emissions. Together, aviation bulk plants (58 percent), non-road vehicles (26 percent), and service stations (9 percent) comprise roughly 93 percent of total alkylated lead emissions.

8.4 References

1. TRC Environmental Corporation. Estimation of Alkylated Lead Emissions, Final Report, prepared under contract 68-D9-0173 for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. September, 1993.
2. U.S. Environmental Protection Agency. Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry. EPA Report No. EPA-450/3-84-012a. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. July, 1984.

Table 8-2

**National 1990 Base Year Alkylated Lead Emissions Estimates
and Major/Area Source Distributions**

| Source Category | Total National Emissions (lb/year) | | Major Source Emissions (lb/yr) ^a | | Area Source Emissions (lb/yr) ^b | |
|--------------------------------------|---------------------------------------|---------------|---|-------------|--|---------------|
| | TEL | TML | TEL | TML | TEL | TML |
| Bulk Plants - Aviation Gasoline | 749.57 | NA | 0 | NA | 749.57 | NA |
| Non-road Vehicles Evaporative | 37.92 | 293.21 | 0 | 0 | 37.92 | 293.21 |
| Service Stations | 12.72 | 102.29 | 0 | 0 | 12.72 | 102.29 |
| Bulk Plants - Motor Vehicle Gasoline | 4.81 | 39.68 | 0 | 0 | 4.81 | 39.68 |
| Bulk Terminals | 3.62 | 29.98 | 0.98 | 8.10 | 2.64 | 21.88 |
| Pipelines | 1.96 | 16.07 | 0 | 0 | 1.96 | 16.07 |
| TOTAL | 810.6 | 481.23 | 0.98 | 8.10 | 809.62 | 473.13 |

^aThese are estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^bThese are estimated national emissions from "area" sources within the source category. "Area" sources are defined in this inventory as any source of HAPs that is not a major source as defined in footnote b above.

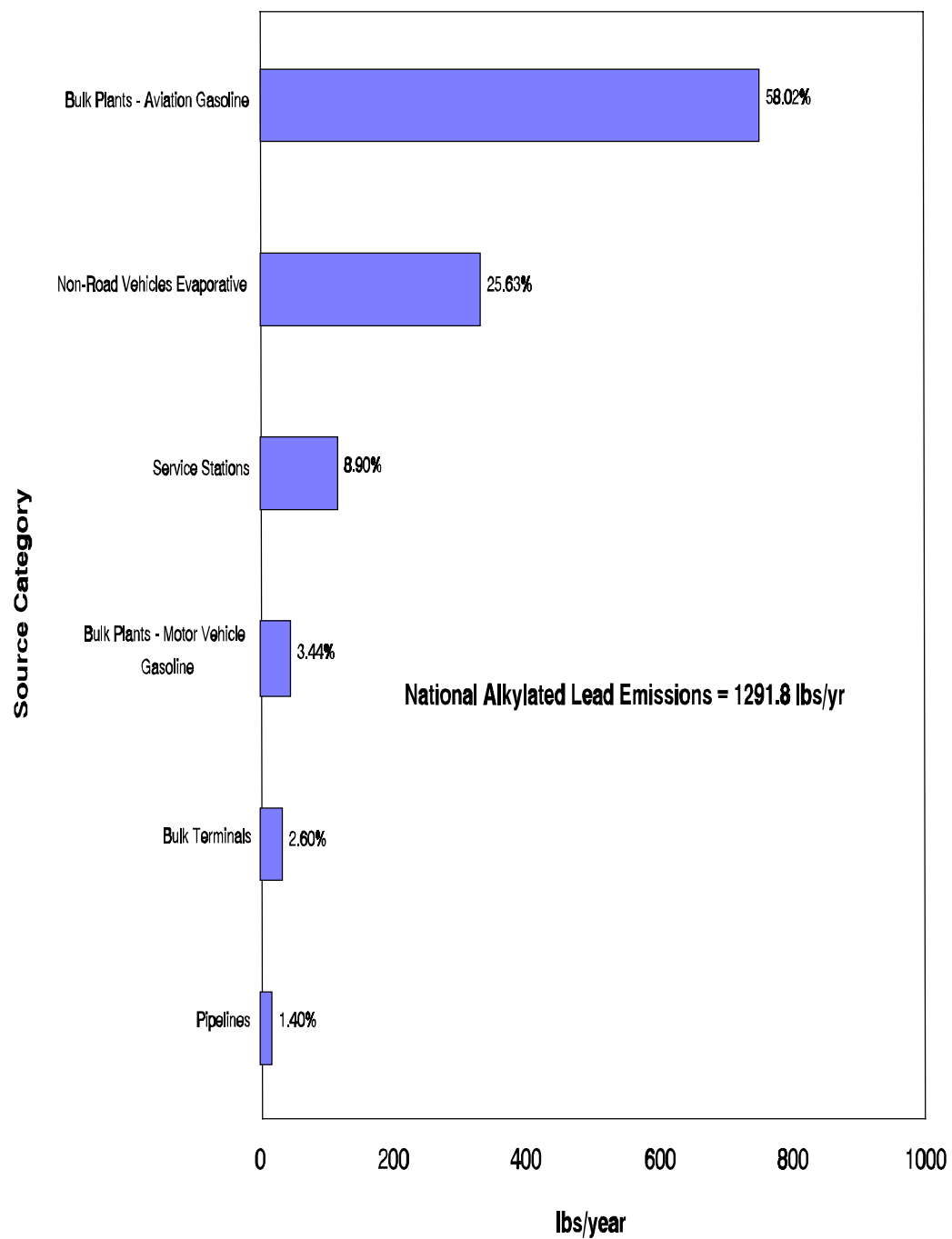


Figure 8-1. Percentage Contribution to 1990 National Alkylated Lead Emissions by Source Category

8.4 References (continued)

3. U.S. Environmental Protection Agency. Draft Regulatory Impact Analysis: Proposed Refueling Emission Regulations for Gasoline-Fueled Motor Vehicles- Volume 1 Analysis of Gasoline Marketing Regulatory Strategies. Office of Air and Radiation. Washington, DC. EPA-450/3-87-001a. July, 1987.
4. U.S. Environmental Protection Agency. Gasoline Distribution Industry (Stage I) - Background Information for Proposed Standards, Draft Report. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. September, 1992.

9.0 INVENTORY DATA GAPS

This chapter identifies data gaps for 112(c)(6) pollutants and source categories in terms of problems that prohibit the determination of reasonable national emissions estimates. Categories that are suspected or known to be emitters of 112(c)(6) pollutants but for which estimates cannot be prepared are identified. The expected relative magnitude of these sources as 112(c)(6) emitters is discussed. The types of data that are needed to produce more complete national 112(c)(6) estimates and the necessary means to obtain these data are also described. This information is presented below on a pollutant basis.

9.1 POM Sources

One of the most significant issues that still remains to be resolved for POM is how to define the pollutant of study. As discussed in Chapter 3.0, there are several ways in which POM has been defined. Standardizing and making emissions source test data consistent will continue to be difficult without a commonly understood and accepted POM definition. The available POM data presented in this document reflect this same dilemma, as evidenced by the documentation in Appendix A and B. Because of this lack of consistent pollutant definition, comparison of existing emission estimates is somewhat imprecise and difficult.

Like several other 112(c)(6) pollutants, POM suffers from a lack of high quality, representative emissions/emission factor data from which to calculate national emission estimates. For many of the combustion source categories, particularly below the utility level, existing data are very limited and of questionable quality. Several of these estimates have been based on emission factors developed from 15-year-old test data collected by differing methods. Additional testing for these source types to produce more category-representative data would improve the national estimates greatly.

Another category that needs additional examination and emissions testing for POM is mobile sources (both onroad and non-road). Some data were available for mobile sources,

but for many of the non-road sources, no estimates could be prepared because of a lack of emissions data or emissions stream speciation data. However, additional POM testing of mobile sources may not be a priority, given recent information provided in ORD's health assessment for diesel emissions that suggests that the primary health risk from particulate POM may be from the inert carbon core of particles rather than the associated organic compounds.

Several other combustion-related categories should also be examined in greater detail for POM purposes. Included here would be metals industry sources (both primary and secondary), steel production, coke ovens, and waste incineration.

In addition to the lack of emissions data in general, the POM situation also suffers from a difficulty to assess the representativeness of the available data to all sources within a category. The very nature of most POM emissions, especially those associated with combustion processes, makes assigning representative factors very difficult. More work is needed to determine the variability of POM emissions from various source types and the reasons for that variability.

9.2 Dioxin/Furan Sources

Like most of the other pollutants, dioxin/furan emission estimates in the national inventory suffer from a lack of extensive emissions data on which to base category-wide estimates. Like POM, data representativeness and variability are key issues. Dioxin/furan emissions for many sources are related to a number of process factors such as temperature, moisture content, chlorine content, etc., that vary from source to source and from time to time within the same source. Obtaining data to better understand and predict these emissions in light of such process conditions will facilitate the development of better emissions estimates. Such understandings will also improve the quality of the source tests that are conducted.

For the purposes of 112(c)(6), there is a lack of emissions data specific to the dioxin and furan species delineated in the Act (2,3,7,8-TCDD and 2,3,7,8-TCDF). This document and most of the other EPA activities related to dioxin/furan have focused on expressing emissions on the TEQ basis. Emissions data on the basis of 2,3,7,8-TCDD and 2,3,7,8-TCDF were not available for all identified source categories. If these individual species will be the focus of 112(c)(6) regulatory activities rather than TEQ estimates, then additional testing will be needed.

The 112(c)(6) national inventory data presented in this document identified most of the categories of dioxins/furans generally thought to be important. Of the identified categories, emissions estimates not quantifiable for ethylene dichloride manufacture, vinyl chloride monomer manufacture, and catalyst regeneration (in petroleum refining). National estimates for landfill gas flares were also not prepared due to a difficulty in obtaining accurate activity level data for the category.

9.3 PCB Sources

The available PCB emissions data from which to prepare the national PCB 112(c)(6) inventory were very limited. All estimates prepared should be viewed as having a high degree of uncertainty. National estimates could not be developed for all categories identified as potential emission sources. Credible estimates were not feasible for the following sources:

- TSDFs;
- Landfills;
- Superfund Sites;
- Steel and Iron Reclamation (auto scrap burning);
- Accidental Releases such as PCB Spills and Transformer Fires; and
- Environmental Sinks of Past PCB Contamination.

Emission factors were not available for most of these categories. For some categories, such as accidental releases, reliable activity data were not available.

In general, estimating emissions of PCBs was the most difficult of all the 112(c)(6) pollutants due to the lack of emissions characterization data. Estimation of air emissions of PCBs from most of these source types has not been a particular research focus, and therefore, data relevant to the objectives of 112(c)(6) are scarce. It is recommended that future testing include PCB as a subject analyte, especially where there are 112(c)(6) source categories overlapping with other pollutants (boilers, incinerators, landfills, etc.). In particular, incinerators and landfills that have been specifically permitted under the Toxic Substances Control Act (TSCA) to handle PCBs at regulated levels (i.e., 50 ppm or greater) should be evaluated.

9.4 Mercury Sources

The draft mercury RTC contained a thorough identification of mercury air emission sources. It is felt that few if any potential air emission source categories remain unidentified. Several of the identified categories, however, do not have emissions estimates, primarily due to insufficient or nonexistent emissions data. The categories that were identified as mercury air sources but for which emissions were not estimated were:

- Mobile Sources;
- Agricultural Burning;
- Landfills;
- Sludge Application;
- Residential Woodstoves;
- Primary Mercury Production;
- Mercury Compounds Production;
- By-product Coke Production;
- Petroleum Refining;

- Zinc Mining;
- Explosives Manufacturing;
- Mercury Catalysts; and
- Natural Sources.

The bulk of the national emissions estimates contained in the RTC document were based on an emission factors and activity levels. The draft report, however, indicates that there are concerns with the emissions/emission factor database available for mercury sources. For a trace pollutant like mercury, only limited data are available, such that it is very difficult to obtain information that is representative for an entire source category. In addition, it was felt that the available data are imprecise and highly uncertain due to problems in measurement techniques and data bias. For most of the source categories addressed, the report listed the “degree of uncertainty” as high. It was also noted that for some of the categories the accuracy and validity of the activity level data is also a concern.

None of these problems are unique to mercury. Emission estimates for several of the other 112(c)(6) pollutants share the same problems. In order to improve the state of the mercury inventory estimates, the draft RTC made the following recommendations:

- Improve the state of available source test data; sources recommended for additional testing include mobile sources, landfills, agricultural burning, sludge application, coke ovens, petroleum refining, residential woodstoves, mercury compounds production, and zinc mining;
- Improve existing emissions information for the categories of secondary mercury production (i.e., recycling), commercial and industrial boilers, electric lamp breakage, iron and steel manufacturing, and primary lead smelting;
- Develop and validate a stack test protocol for speciated mercury emissions;
- Improve the state of knowledge on coal cleaning and mercury removal, and the potential for slurries from the process to be a mercury source;
- Improve the state of knowledge on the levels of mercury found in coals and petroleum used in the United States;

- Conduct more research to address the potential for methylmercury to be emitted or formed in the flue gas of combustion sources; and
- Investigate the importance to air concentrations of mercury re-emitted from deposited anthropogenic emissions and mining wastes.

9.5 HCB Sources

One of the major contributors to HCB emissions was chlorinated solvent production, which encompasses several individual chemical products. The national inventory estimates for these products came from data reported in the TRI database. HCB air emissions estimates were developed based on total environment HCB releases reported in the database. The most significant problem with this method was that not all applicable chemical facilities had data reported in TRI. This required that emissions extrapolations be made to those facilities based on the ones that were in the database. This extrapolation process introduces additional sources of possible error into the national HCB estimates. The chemicals that were studied as a part of the TRI approach were carbon tetrachloride, perchloroethylene, trichloroethylene, ethylene dichloride, and 1,1,1-trichloroethane.

An additional 29 chemical products/processes were also suspected of being sources that contained HCB as a contaminant/by-product; however, no information could be identified to verify the levels of contamination or estimate potential HCB releases for these facility types. The 29 chemicals/products identified were:

- | | |
|---------------------------|---------------------------------|
| • aluminum | • pentachlorobenzene |
| • azo dyes | • pentachlorophenol |
| • benzyl chloride | • phosgene |
| • chlorinated biphenyls | • phthalic anhydride |
| • chlorinated naphthalene | • phthalocyanine dyes/pigments |
| • chlorinated paraffins | • polyethylene |
| • chlorine | • polypropylene |
| • chloroprene | • sodium chlorate |
| • chloropropane, 3- | • synthetic rubber production |
| • cyanuric chloride | • tetrachlorophthalic anhydride |
| • dichloropropenes | • titanium dioxide |

- electrode manufacture
- ethyl chloride
- fluorocarbon 113
- maleic hydrazine
- toluene diisocyanate
- ordnance and pyrotechnics

One problem with the development of HCB emission estimates involved a lack of data on HCB contamination levels in various chemical products, and a lack of chemical specific production/activity data from which to estimate national emissions due to proprietary data concerns. One of the other quantifiable categories of HCB air releases was determined to be pesticides production and use. Seven pesticides were identified as being the chief ones containing HCB as an impurity. These seven include Dacthal (DCPA), pentachloronitrobenzene (PCNB), propazine, simazine, chlorothalonil (daconil), picloram, and atrazine. Pesticide application information was not available for daconil, and only limited data were available for PCNB and propazine. Production data for all pesticides manufacture (which could have been useful in estimating application rates) were not available due to the proprietary nature of the commercial chemical information.

9.6 Alkylated Lead Sources

The most significant inventory data gap for the alkylated lead sources is that three source categories could not be inventoried due to a lack of credible information. These three are aircraft emissions, alkylated lead production emissions, and onroad motor vehicle emissions. Given the alkylated lead content of aviation fuel, evaporative and combustion emissions associated with aircraft could be a relatively significant emissions source not included in the 112(c)(6) inventory. Emissions from aircraft refueling were evaluated; however, no process-specific emission factor could be determined and a surrogate based on motor vehicles had to be used. The effect of this data deficiency on the emissions estimate cannot be determined without more in-depth research.

In general, the methods used to estimate 112(c)(6) alkylated lead emissions were based on the use of gasoline distribution industry emission factors and gasoline throughput

activity data. The estimates derived from this method are susceptible to the same problems as any others based on this technique, including validity and representativeness of the emission factors and accuracy of the activity data. Further study should probably be focused on assessing the factors used, since gasoline production and use data are collected and tracked for several purposes and by several agencies such that the activity data are reasonably reliable.